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CHEMICAL EXPERIMENTS;

ILLUSTRATING
THE THEORY, PRACTICE, AND APPLICATION
OF THE
SCIENCE OF CHEMISTRY,
AND CONTAINING THE
PROPERTIES, USES, MANUFACTURE, PURIFICATION, AND ANALYSIS
OF
ALL INORGANIC SUBSTANCES.

WITH
NUMEROUS ENGRAVINGS OF APPARATUS, &c.

BY

G. FRANCIS, F.L.S.

AUTHOR OF THE DICTIONARY OF ARTS AND SCIENCES, THE ANALYSIS OF BRITISH FERNS, THE LITTLE ENGLISH FLORA, GRAMMAR OF BOTANY, ETC.

LONDON:
G. BERGER, HOLYWELL STREET, STRAND.

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PREFACE.

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It has not been thought necessary to describe the properties of the very rarest substances, nor yet to enter into the minutiæ of organic chemistry, such additions would have increased the size and price of the work without a corresponding *practical* value; for the same reason no allusion has been made to some recent theories of analysis; for example, the new composition of ammonia. It is right to leave these erudite matters to larger works, and to the oral instruction of our learned chemical professors. My object has been in this work, as in all others which I have previously published on science, to collect the most solid and practically useful information, to present this in as alluring a form as the nature of the subject will admit, and to keep the whole within such a space and price as to render the work accessible to all.

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These changes show equally the nature and the cause of this action, and exhibit to us, at the same time, many of the important facts of chemistry; for example, in burning the charcoal, heat has converted a part of the carbon, (or charcoal,) into a gas, called carbonic acid gas; this it has done by decomposing the air around the burning material. The oxygen of that air has united chemically to the carbon, forming the gas mentioned above. While the charcoal remained cold, this chemical action did not take place. Again, the combustion only continued for a certain time; as long, in fact, as chemical action could go on. It then ceased, and left substances unchangeable by heat; namely, the potass and the earth. Yet a different chemical alteration took place on the addition of water, and a salt of potass was procured. Fire, which had no effect before, now produced another change; the carbonate of potass was partly decomposed, and it became pure potass. While by the influence of electricity potass was further changed, and its ultimate composition ascertained to be an elemental substance, called potassium, united to another element, called oxygen. If we had soaked the wood in water previous to the making of it into charcoal; or soaked the charcoal in water, previous to its burning, no potass would be separated from it—so also though wood soon perishes by exposure to the air or water, yet charcoal is imperishable in either.

These general illustrations show that chemical action takes place only under certain circumstances; that some bodies have no tendency to unite chemically; and that others strongly influence each other's properties. The former are said to have no *affinity* for each other; their mixture is merely mechanical, and no change of properties takes place. The latter class of bodies act by their affinity for each other, their mixture is productive of chemical phenomena, and the properties of one or both are altered.

The degree of chemical action exercised by bodies upon each other is exceedingly varied, and so also is the time requisite for that action to take place. In some instances many days or even weeks and years pass away before its effects become visible. The spontaneous decay of animals and vegetables, the disintegration of rocks, the oxydation of iron, and still more so of lead and copper, by contact with the air, all of which are chemical processes, show the slow and gradual progress of chemical action. While the varied effects of effervescence, combustion, and explosion, illustrate how suddenly chemical action sometimes proceeds. The effect produced is often but little removed from a mere mechanical operation, and the change of properties inconsiderable: thus it is in solutions and decoctions. At other times it is impossible to recognize the components in the compound from them. Bodies have often an affinity for each other in one state, though not in another; frequently the admixture of a third body is requisite to promote their union. In most instances increase of temperature greatly aids chemical action, even light is frequently productive of the same effect; and in all cases it is absolutely necessary that each body should be in a state of minute division: thus two solids combine with difficulty—a solid and fluid more easily—and two fluids with yet greater facility.

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Chap. 1—Chemical action, operations, and manipulations
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CHAP. I.

CHEMICAL ACTION, OPERATIONS, AND MANIPULATIONS.

It is the fundamental principle of all physical knowledge that we can create nothing and destroy nothing. We may change the fashion and properties of all things, but to form new laws of combination, or new species of matter, belongs to the Creator alone. The utmost man can do is to develop, and to apply to his own use and benefit those properties and materials, which the constitution of already-created things afford him. Nay more, there is no reason to suppose that a single atom of matter has been added to or taken from the earth since its first formation; yet changes are incessant, some natural, others artificial. Some few of them mechanical, but the greater number, and those of greatest moment, chemical. The minute seed placed in the ground becomes in process of time a gigantic tree, yet not one particle of its wood did not previously exist in some other state, it has been derived from the earth and atmosphere. Moisture and carbon have, by the vital action of the vegetable, been united, and have formed woody fibre, oils, acids, resins, sugars, gums, salts, &c. We may fashion the trunk into a house, a boat, a plough; no change in properties takes place, but merely an alteration of form—in fact, a mechanical action only is occasioned. Still nature will exert her influence; houses, boats, and ploughs will decay, and become eventually changed into their chemical elements—in fact, into earth, fit to supply other trees with proper nourishment. Again,

INTRODUCTION

Experimental philosophy is usually considered as that great department of human knowledge, which is learnt by means of trials or experiments, and the deductions of which appeal to our *bodily senses;* such as chemistry. Mathematical philosophy, on the contrary, appeals to our *reason* only, and includes those sciences which show the properties of abstract quantities, numbers, or durations, as arithmetic, geometry, &c.

These very different classes often act totally independent of each other, as in the above illustrations; but more often the facts of the experimental sciences admit, nay require, a mathematical explanation; hence a third kind of philosophy, properly called *mixed*, arises. This third class is of the greatest extent, and includes most of the subjects of natural philosophy, such as mechanics, pneumatics, hydrostatics, optics, &c. In the study of these sciences experiment and calculation should go hand in hand; our senses see the effects, and our reason explains them by mathematical truth.

As experiments appeal to our senses, so the objects of them must be material, or else such influences as affect in a sensible degree the particles of matter. Under the general term matter is included all substances whatever, whether simple or compound, fluid or solid, of which the universe consists, and of which every thing within it is formed. All these bodies have properties peculiar to themselves, and by which the one is distinguished from the other. They have also properties in common, and are acted upon by certain laws of nature, particularly by those of attraction and repulsion.

Besides the above, there are certain powers of nature, which are known only by their effects. Whether really material or not is doubtful, yet the great and perceptible influence they have upon material bodies renders them also the frequent subject of experiment. These being without appreciable weight are called *imponderables;* they are light, heat, and electricity—the last word including all the phenomena known as electrical, galvanic, and magnetic.

Not only do the powers of nature exercise considerable effects upon matter in general, but different kinds of matter exert a more or less powerful influence over each other; hence the cause of all the changes, natural and artificial, which take place in the material world. Bodies thus influencing others are said to *act upon* them, and the action is called *physical* or *chemical*, according to the phenomena produced. If two or more bodies act upon each other, so slightly that neither of them becomes altered in properties, the action is merely physical; if either or all of the bodies are changed in character, the

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Ex.—Pound a small piece of sulphur in a warm stone mortar. It will become a powder, and adhere to the sides of the mortar so strongly, that the mortar may be reversed without losing the sulphur. If the mortar be now gradually heated, the sulphur will first be melted, and afterwards burst into flame, when an intense blue color will be emitted. In this experiment the pounding is a *mechanical* action ; the adherence of the powder to the mortar is *electrical ;* the melting and burning are *chemical* effects, arising from the application of heat ; while the light given off is *optical*, arising from the intensity of the chemical action. Thus in one experiment there are three physical and two chemical actions.

Other experiments might have been adduced, equally comprehensive. The following are more limited, and show the different kinds of action, as much as possible independent of each other :—

Ex.—Suspend several balls by strings, so as just to touch each other. Lift up the end one A, and then let it fall upon the rest. The consequence will be that the more distant ball will be driven off. The effect is here purely mechanical, for although all the balls receive and transmit the impulse, yet none of them are altered in properties.

Ex.—Rub briskly a warm glass tube, with a warm flannel, and hold it towards two feathers, suspended from a wire by two fine silk threads, and it will immediately attract them, showing an electrical action ; in this no permanent change in any body takes place.

Ex.—Blow a common soap bubble, and let it ascend in the air, or else pour a drop of oil upon a pond of water ; the most brilliant colors will, in both instances, be exhibited. This is an *optical* action ; the result of a peculiar reflection of light, and is not caused by either chemical or mechanical changes. The ascent of the soap bubble is mechanical, being merely the result of the less specific gravity of the bubble compared to the air.

Ex.—Add vinegar to chalk ; the chalk will be dissolved, forming with the vinegar a peculiar salt, different in its nature from either of its constituents ; this is, therefore, a chemical action.

Ex.—Lay a piece of Iceland spar upon some letters, they will appear double ; this is also an optical phenomenon, caused by a double refraction of the rays of light.

Ex.—Support a bar magnet on a stand, and hold a nail towards each end of it. These nails will by mere contact become magnets also, as may be proved by holding iron filings near the lower ends of them ; the iron filings being taken up by the nails. This effect is *magnetic*, or a division of electrical action. It being a physical property that iron in contact with a magnet becomes a magnet also.

CHEMISTRY,

EXPERIMENTAL AND PRACTICAL.

CHEMISTRY shows the inherent nature of all material substances, and the laws which regulate their composition and decomposition.

The principles and facts of chemistry are the foundation of many of our trades and manufactures; as the smelting, refining, working, and combination of metals; the distillation of essential oils, spirits, and acids; the processes of dyeing, bleaching, tanning, and brewing, besides those used in the preparation and preservation of food; the analysis of soils and mineral waters; the manufacture of gas for illumination, cements for building, glass and porcelain, soaps, inks, salt, gunpowder, and a thousand materials and combinations used in the arts of life. No less dependent on chemistry are the fine arts; etching on copper and on steel; lithography; enamel and encaustic painting; staining glass; and the preparation of pigments and varnishes are among its objects of inquiry.

Those natural phenomena which are of most frequent occurrence, and which most modify the climate and constitution of the globe are always attended, if not caused, by chemical change; for it is to this science that we are indebted for an explanation of all the multitudinous effects of combustion, crystallization, fermentation, evaporation, and condensation. Were it not for chemistry the functions of secretion, digestion, sanguinification, respiration, and many others, the result of vital action, would remain unexplained; the cause of diseases unknown; the ravages of poisons unmolested; and medicine, which owes all its force and efficacy to a correct knowledge of the effect of inorganic substances upon vital functions, would still be, what it once was, a tissue of absurdities, and a display of nought but the most ignorant tampering with human life and human happiness.

Chemistry is, from its extensive application, and the nature and multiplicity of the objects which it embraces, essentially a science of experiment and amusement. Not dependent upon any other science for an explanation of its principles, and its facts not to be anticipated by mathematical reasoning; trials, or in other words, experiments alone have raised it to its present extent and perfection. These only have enabled chemists to ascertain the nature of material substances, and the apparent laws of their combinations, and nothing but fresh experiments can possibly produce new facts and new principles.

It is no less true that chemistry is pre-eminently a science of amusement; the extraordinary nature of chemical action, the contrary characters of the fundamental elements, and their almost endless combinations, give such varied interest to the subject, that the mind is insensibly attracted and diverted, at the same time it is imbibing valuable knowledge. Most persons are aware of all this, and have even long and ardently desired to study this fascinating science, but have been deterred from the want of a guide in the outset of their career, or from the impression that chemistry is expensive, and difficult of attainment. Nothing can be more erroneous than this surmise; on the contrary, compared to any other extensive science whatever, this may be studied *most cheaply*. All the apparatus requisite are of the simplest and cheapest character. A few wine glasses, a pestle and mortar, a few Florence oil flasks, a stand, an ordinary lamp, a gas jar, a gas holder, (and which may be a common bladder,) an iron bottle for making oxygen, and some crucibles, are almost all that are absolutely required for the majority of experiments; and although numerous others will be described hereafter, yet very often simpler implements may be substituted. The ingredients and materials will require an outlay of but a few shillings, as the young student will soon learn to distinguish such as are of frequent use from articles of mere curiosity. The latter he will often make for himself. The former, such as sulphuric acid, (oil of vitriol;) hydrochloric acid, (spirits of salts;) nitric acid, (aqua-fortis;) the common metals, alkalies, oxydes, salts, &c., are procurable at most chemist's shops for a mere trifle. Almost all of these may be kept in pill-boxes, or phials; those holding the corrosive acids, and a few others, alone having glass stoppers.

Should it be asked—How is chemistry to be studied? The answer is easy—perform its experiments. If the character of a substance be already well ascertained, read that character, and then prove it by experiments. These will impress the facts upon your memory, and perhaps elicit new. These, and these alone, will give that habit of manipulation and observation, carefulness, research, and comparison, which make a chemist.

Order in the method of study is no less necessary. To see or even to perform ever so extended a series of experiments, provided such are unconnected with each other, leads to little useful results; but if such are properly classified, and varied so as to meet all requirements and contingencies, then, by showing a fact or principle under such numerous phases, the judgment and memory is no less assisted than the senses are gratified. The following experiments, therefore, are carefully arranged; and the general subject so divided, as to lead to the ready understanding of its various important principles of utility. The following is the order in which the science will be treated:—

PRINCIPLES OF CHEMISTRY.

1—Chemical action, operations and manipulations.
2—Chemical elements, or simple substances.
3—Laws of chemical combinations, the atomic theory, &c.
4—Simple affinity; alloys, amalgams, oxydes, acids, earths, alkalis, sulphurets, salts, compound gases, &c. &c.
5—Elective or compound affinity; tests, and re-agents.
6—Crystallization.
7—Effects of heat, light and electricity; detonating compounds, &c.
8—The chemistry of organic substances.

APPLICATION OF CHEMISTRY.

9—Application to the medical sciences.
10— ,, manufactures and domestic arts.
11— ,, the fine and ornamental arts.
12— ,, natural philosophy.
13— ,, natural history, agriculture, &c.
14—Miscellaneous operations and experiments.

CHEMICAL ACTION, OPERATIONS, AND MANIPULATIONS.

It is the fundamental principle of all physical knowledge that we can create nothing and destroy nothing. We may change the fashion and properties of all things, but to form new laws of combination, or new species of matter, belongs to the Creator alone. The utmost man can do is to develop, and to apply to his own use and benefit those properties and materials, which the constitution of already-created things afford him. Nay more, there is no reason to suppose that a single atom of matter has been added to or taken from the earth since its first formation; yet changes are incessant, some natural, others artificial. Some few of them mechanical, but the greater number, and those of greatest moment, chemical. The minute seed placed in the ground becomes in process of time a gigantic tree, yet not one particle of its wood did not previously exist in some other state, it has been derived from the earth and atmosphere. Moisture and carbon have, by the vital action of the vegetable, been united, and have formed woody fibre, oils, acids, resins, sugars, gums, salts, &c. We may fashion the trunk into a house, a boat, a plough; no change in properties takes place, but merely an alteration of form—in fact, a mechanical action only is occasioned. Still nature will exert her influence; houses, boats, and ploughs will decay, and become eventually changed into their chemical elements—in fact, into earth, fit to supply other trees with proper nourishment. Again,

we may distil the branches and procure pyroligneous acid, and gas and charcoal. We may burn the charcoal, and produce sensible light and heat, and carbonic acid gas. Being burnt, we may by washing the ashes procure potass. The potass is still a compound body, which by the aid of electricity may be resolved into its elements, potassium and oxygen. Thus vital action, natural decay, artificial combustion, and electricity, have been equally the cause of chemical composition and decomposition, or in other words of *chemical action.*

These changes show equally the nature and the cause of this action, and exhibit to us, at the same time, many of the important facts of chemistry; for example, in burning the charcoal, heat has converted a part of the carbon, (or charcoal,) into a gas, called carbonic acid gas; this it has done by decomposing the air around the burning material. The oxygen of that air has united chemically to the carbon, forming the gas mentioned above. While the charcoal remained cold, this chemical action did not take place. Again, the combustion only continued for a certain time; as long, in fact, as chemical action could go on. It then ceased, and left substances unchangeable by heat; namely, the potass and the earth. Yet a different chemical alteration took place on the addition of water, and a salt of potass was procured. Fire, which had no effect before, now produced another change; the carbonate of potass was partly decomposed, and it became pure potass. While by the influence of electricity potass was further changed, and its ultimate composition ascertained to be an elemental substance, called potassium, united to another element, called oxygen. If we had soaked the wood in water previous to the making of it into charcoal; or soaked the charcoal in water, previous to its burning, no potass would be separated from it—so also though wood soon perishes by exposure to the air or water, yet charcoal is imperishable in either.

These general illustrations show that chemical action takes place only under certain circumstances; that some bodies have no tendency to unite chemically; and that others strongly influence each other's properties. The former are said to have no *affinity* for each other; their mixture is merely mechanical, and no change of properties takes place. The latter class of bodies act by their affinity for each other, their mixture is productive of chemical phenomena, and the properties of one or both are altered.

The degree of chemical action exercised by bodies upon each other is exceedingly varied, and so also is the time requisite for that action to take place. In some instances many days or even weeks and years pass away before its effects become visible. The spontaneous decay of animals and vegetables, the disintegration of rocks, the oxydation of iron, and still more so of lead and copper, by contact with the air, all of which are chemical processes, show the slow and gradual progress of chemical action. While the varied effects of effervescence, combustion, and explosion, illustrate how suddenly chemical action sometimes proceeds. The effect produced is often but little removed from a mere mechanical operation, and the change of properties inconsiderable: thus it is in solutions and decoctions. At other times it is impossible to recognize the components in the compound from them. Bodies have often an affinity for each other in one state, though not in another; frequently the admixture of a third body is requisite to promote their union. In most instances increase of temperature greatly aids chemical action, even light is frequently productive of the same effect; and in all cases it is absolutely necessary that each body should be in a state of minute division: thus two solids combine with difficulty—a solid and fluid more easily—and two fluids with yet greater facility.

Chemical action alters not merely the nature of bodies, but very frequently their form also, as may be seen by many of the following experiments: thus solids are sometimes formed from gases and from liquids—liquids from solids and gases—and gases themselves are invariably produced from either one or other of these distinct classes. It is productive also, in many instances, of great alteration of temperature, of volume and specific gravity, of color, and of taste.

Ex. 1. *Oil and Water a mechanical mixture.*—Mix together oil and water in a phial; however much these may be shaken together the action is merely mechanical, as will be seen by their soon separating—the oil resting upon the top of the water as at first.

2. *Soap a mechanical compound.*—Add to the oil and water, a little pearl ash: shake the phial as before, and the three will unite chemically, forming soap.

3. Take two leaden bullets, cut a small piece off each, and press the two bright surfaces together with a strong pressure, screwing the bullets somewhat round at the same time; they will adhere strongly without any chemical action. Now melt them in a ladle over a fire, and they will not merely adhere, but become chemically blended with each other.

4. *The phial of the four elements*, as it is called, is an example of mechanical action. It is made thus:—Take a phial, about 6 or 7 inches long, and about ¾ of an inch in diameter. In this phial put, first, iron or copper filings; secondly, chalk or whitening; next, colored water; and lastly, oil. These being of different densities, and having no chemical affinity for each other, will soon settle as at first, however much the vessel may be shaken.

5. *Chemical union of four bodies.*—Instead of the oil, pour gently into the phial nitric acid. It will be seen to unite chemically with the metal, the chalk, and the water, making the whole a blueish homogeneous mass.

6. *Slow action of the atmosphere upon iron.*—Let a piece of brightened iron lay exposed to the weather, if wet it will be soon rusted, if dry some considerable time will elapse before this takes place.

7. *Gradual absorption of water by lime.*—Quick lime left exposed to the air becomes gradually slaked or chemically united with water, by depriving the atmosphere of any moisture which may be suspended in it.

8. *Gradual change caused by fermentation.*—Mix a pound of raw sugar with a gallon of water; in a few days fermentation will ensue, which will change the whole into vinegar.

9. *Chemical effect of light.*—Wash a piece of paper over with a strong solution of nitrate of silver; dry it in the dark, and when dry expose it to the sun's light; though colorless before it will now soon become black. The effect will be much more rapid, if the paper be first dipped in very weak salt and water, it will then be photogenic paper, and a picture may be made by placing a dried plant, feather, bit of lace, &c., upon it, previous to its exposure to light.

10. *Chemical action shown by heat.*—Place a crystal of nitrate of ammonia in a fire shovel over a quick fire; when it has arrived at a heat sufficient for melting lead, it will in the act of decomposition explode with considerable violence. Over a slow fire it will boil away, giving off fumes of the nitrous oxyde, or laughing gas.

11. *Formation of sulphuret of iron.*—Hold a roll of sulphur to a bar of cold iron, they remain without uniting; but bring the iron bar to a red heat, and apply the sulphur as before, it will now unite with the iron, rendering it extremely brittle—the iron being changed into the sulphuret, while a considerable portion of light and heat will be extricated.

12. *Formation of glass.*—Mix together sand and potass; while cold no change is apparent, but heat them with the flame of a candle, urged with a blow-pipe, or else in the fire, and they will unite and form glass.

13. *Combustion of nitrate of copper.*—Wrap up some crystals of nitrate of copper in tin foil, while dry no chemical union takes place, but moisten them with water, and soon the whole bursts into flame.

14. *Extemporaneous soda water.*—Mix together half a tea spoonful each of the dry powders of carbonate of soda and tartaric acid; in this state they have no chemical affinity for each other, but dissolve each previously in water, and the union of the two solutions will be attended by violent ebullition; in fact, the mixture is the well-known saline draught, or soda water.

15. Mix together loaf sugar and chlorate of potass; of themselves they do not chemically combine, but touch them with a drop of sulphuric acid, and a most vivid combustion will ensue.

16. *Two gases form a solid.*—Brush the inside of a tumbler with a feather dipped in hydrochloric acid; wet another tumbler in the same manner with liquid ammonia. If now one tumbler be inverted over the other, the two invisible gases which are emitted unite and form an opaque solid, which is the chloride of ammonia or sal ammoniac. It will appear in the glasses as white fumes.

17. *Two liquids form a solid.*—Put into a glass a few spoonsful of a saturated solution of chloride of lime, and add to it gradually, drop by drop, sulphuric acid. If these two liquids be stirred together with a glass rod, they become converted into an opaque, white, and almost solid mass.

18. *Two solids form a liquid.*—Put into a mortar 2 drams of sulphate of soda and 2 drams of nitrate of ammonia. These substances when rubbed together will gradually become fluid.

19. *Two liquids vaporized by mixture.*—Pour upon some strong spirits of wine an equal quantity of fuming nitrous acid, the chemical action will be so energetic that the whole will be dissipated into vapor.

20. *A gas formed from a solid.*—Subject a piece of marble to a red heat in a fire, and carbonic acid gas will be given off in abundance. The marble being changed at the same time into quick-lime.

21. Fill the bowl of a common tobacco-pipe with coal dust, cover it with sand or clay, and place it in the fire; when hot, carburetted hydrogen gas will be evolved, and may be lighted at the end of the stem of the pipe.

22. *Gases formed from a liquid.*—Put some damp ashes upon a hot fire, and a blue flame will be seen playing upon the top of them, showing that the water has been decomposed into its two constituent gases, oxygen and hydrogen. The former goes to feed the fire, the latter is liberated, and burns at the top. When water is decomposed by galvanism, both gases are obtained.

23. Let nitric acid pass slowly through a red-hot earthenware tube, and it will be decomposed, giving off oxygen gas, and nitrous oxyde gas; and thus here also two gases have been formed from a liquid.

24. Put a little common salt in a saucer, pour upon it a tea spoonful of sulphuric acid; stir it up, and place the saucer on the hob of a stove. When hot, cover the saucer over with a glass jar, which has a sprig of parsley hanging in it. The fumes which arise from the mixture are chlorine, or the bleaching gas; they are the result of a chemical action, and will soon take out the whole color from the parsley leaf—thus occasioning another chemical action.

25. *Two pints may be less than a quart.*—Into a quart measure put a pint of spirits of wine, and upon this a pint of water; stir them together, they will become warm, but not fill the measure.

26. *Clearing away of snow by salt.*—Mix together equal parts of snow and salt. The two will unite and form a liquid—colder than either of the two before mixing.

Note.—Salt is often sprinkled upon snow to clear the pathways, &c. So great a degree of cold is produced by the mixture, that if not swept off immediately, the brine that remains will penetrate the shoes, and chill the feet of the traveller, infinitely more than the snow would have done.

27 *Change of color.*—To a solution of galls, add a solution of sulphate of iron, both nearly colorless, and black ink will be formed; add some hydrochloric acid, the black color will disappear, and the solution become colorless again.

28. Make a very weak solution of sulphate of copper, and add to it liquid ammonia: it will become of a most beautiful blue color, such as we see in the shop windows of the chemists.

29. *Change of taste.*—Sulphuric acid is in the highest degree sour and corrosive—potass has an extremely nauseous alkaline taste. Mix these together, and they will make the nearly tasteless sulphate of potass.

30. *Change of smell.*—Nitric acid has a most pungent odour, and liquid ammonia one not less powerful. Mix these together in such proportions that they neutralize each other—a perfectly scentless salt will be obtained, the nitrate of ammonia. Ammonia itself, though so pungent in odour, is formed from two scentless gases, hydrogen and nitrogen.

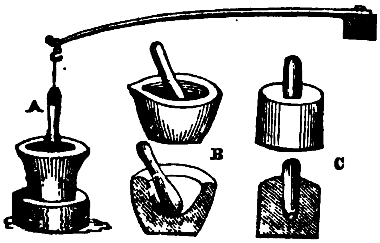
31. Pound in a mortar, or rub together on a board, a small piece of lime, and an equal quantity of sal ammoniac. They will unite, and although separately they have no scent, yet when combined a powerful odour of smelling salts will be given off.

The above experiments exhibit chemical action under numerous of its phases, showing how different are the causes which produce it, and at the same time how contradictory, and often unexpected, is the result of chemical combination and decomposition. An explanation of each operation would have been premature; and, except to the chemist, unintelligible, until the nature and peculiar characteristics of the chemical elements had been pointed out and compared. They will then form a subject of future consideration.

The means taken to produce chemical action, the operations necessary in performing experiments, and the results of them, are known by a multitude of names, which it is absolutely necessary for the young chemist to be acquainted with, more especially as they involve the whole manipulation of the science. Indeed no exercise is more useful than to consider each in detail, and to show how each is to be caused and performed, the following may render this more clear :—

COMMINUTION AND TRITURATION

Is the reducing a solid mass into minute particles. For this operation nothing is more convenient for ordinary purposes than the pestle and mortar. If the substance be very hard and large, iron mortars may be employed; for other uses, a Wedgewood mortar. This, if well made and of good materials, will not become stained by solutions of the colored salts, such as blue stone ; will not be ground away by use ; and scarcely become scratched by a sharp edge of quartz, or steel. Mortars are also made of porphyry, agate, and glass. The pestle should be of the same material as the mortar, and its bulb about $\frac{1}{2}$ the diameter of the mortar. For breaking diamonds, the pestle fits the cavity of the mortar exactly, in order that the diamond dust should not be lost. Diamonds are broken by the blow of a hammer on the top of the pestle.



A, large mortar ; the pestle being drawn up by a spring appended to the ceiling. B, section of the Wedgewood mortar. C, ditto of the diamond mortar.

Comminution and trituration are performed by blows of the pestle; pulverization is effected by rubbing the point of the pestle around the sides of the mortar.

Ex. 32. *Preparation of silica.*—Put a flint in the fire, and there let it remain until it is calcined ; that is, burnt to a white mass ; throw it while red hot into cold water. Pound this substance in a mortar to a fine powder ; it is nearly pure silica, and may be preserved as such. Rock crystal thus used is still more pure silica. It cannot be pounded by this means perfectly fine. To obtain it in a state of more minute division, see *Silica*.

33. *Trituration of certain metals.*—Pound in an iron mortar some zinc ; while the metal remains cold this is very difficult, but make both it and the mortar hot, and the process is easy. Keep it as granulated zinc.

The granulation of the other brittle metals, antimony, bismuth, &c., is also assisted by heat, but it is not so necessary with these as with zinc. The malleable metals, platinum, gold, silver, copper, &c., cannot be pulverized. They must, if wanted in fine particles, be procured in the state of leaf, of wire, or else granulated by a file. All metals may be obtained in small pieces, like shots, by melting them, and pouring the melted metal by drops into a deep vessel of cold water.

34. *Pulverizing camphor.*—Pound some camphor ; this has a roughness under the pestle, and must have a few drops of spirits of wine added to it. To obtain it in a finer powder, see *Precipitation*.

35. *Pulverizing the gums.*—Pound some gum arabic or gum tragacanth. You will fail in this, unless the gum be previously made perfectly dry, and even warm.

36. *Pulverizing charcoal.*—Pound some charcoal; this is by no means easy, if the charcoal is cold, but if ignited it may be very readily pulverized. Therefore when powdered charcoal is wanted, use a piece out of a charcoal fire, cutting off the ignited portions.

37. *Pulverizing resinous substances.*—Some kinds of pitch, turpentine, &c., are easily pulverized ; others are so adhesive that they will adhere to the mortar. To avoid this it is often necessary to put glass dust, or fine sand, into the mortar with them, in order to keep the particles asunder. The sand, or glass, if likely to be injurious, may be washed out afterwards. Resins are triturated best when very cold, or under water. Resins when required in chemical arts are not often pulverized, but are reduced merely to a coarse powder.

38. *Pulverizing prevents decrepitation.*—Throw some coarse common rock salt, or bay salt upon the fire ; it will be seen to decrepitate, that is, to fly about in small particles with a crackling noise. Pulverize another portion of the same salt, and throwing some of it also upon the fire, no crackling will ensue. This experiment shows the necessity of pulverizing substances for other purposes than a more accurate mixing of them, as for solutions ; and also explains the nature of decrepitation, proving that it arises from the

outer surface of the large grains of the salt becoming heated before the inner portion, consequently the unequal expansion of the particles occasion their separation, or that it arises from the particles of moisture in the interior of the grains being expanded, drives off the outer covering of them.

Note.—Most chemical compound solids, except those of a waxy consistence, such as potassium, phosphorus, &c., may be pulverized, and, with the exception of the fulminates, most of them without danger. But very great care must be taken in pounding two or more bodies together, lest an explosion should take place. This is particularly the case when a nitrate, chlorate, or iodate, is one of the substances. The peculiar nature of the fulminates will be treated of hereafter. As a familiar instance of their effects we may allude particularly to the percussion caps of fire arms, Waterloo crackers, &c. The following require very great care, particularly to use only a small quantity of the ingredients. The quantities mentioned are the utmost that can be operated upon with safety.

39. *The nitrates explode with phosphorus by percussion.*—Triturate in a mortar 2 grains of phosphorus, with 4 of nitrate of bismuth: during the operation violent detonations will take place.

40. Pulverize 6 grains of the nitrate of silver, (lunar caustic,) or 12 grains of the nitrate of copper, or 4 grains of the nitrate of mercury, or 10 grains of the nitrate of potass; and mix with either one of these quantities 2 grains of phosphorus. Wrap the mixture in paper, lay it on an anvil, and strike it smartly with a *hot* hammer—detonation will ensue.

41. *The nitrates detonate with sulphur by percussion.*—Reduce to powder 10 grains of nitrate of silver, and then mix with it 4 grains of sulphur. Wrap the mixture in a small piece of paper, and place it upon an anvil; heat a flat-faced hammer, and strike the mixture with it—a violent explosion will take place, and upon examination the silver will be found in a partly reduced or metallic state. If the hammer be cold, the sulphur only will be affected; it will then inflame without detonation.

42. The same may be performed with the nitrate of lead and sulphur, using 6 grains of each. Percussion is not here necessary. Heat an iron mortar; then triturate the mixture with the pestle smartly, and various small explosions will take place, and the lead will resume its metallic state.

43. When in a case like this the metal resumes its original form, nitrogen leaves the salt, and becomes gaseous from combination with the caloric evolved in the decomposition. The oxygen of the nitric acid being also free combines with the sulphur, and flies off in the state of sulphurous acid gas.

44. *The nitrates detonate with charcoal by percussion.*—If 10 grains of charcoal, in powder, be mixed with 10 grains of nitrate of silver, also in powder, and laid on an anvil, wrapped up in paper; an explosion will take place when they are smartly struck by a hot hammer.

45. *The chlorates explode with charcoal by percussion.*—If 2 grains of powdered charcoal and 4 grains of chlorate of potass be carefully mixed in a piece of paper, then folded up, and placed upon an anvil—upon being struck by a hammer a violent detonation will take place.

In this and some other of the following experiments, the two bodies being brought into closer union, the salt parts with its chlorine, which combines with the combustible; at the same time the whole becoming elastic suddenly repels the surrounding air, causing explosion.

46. *Chlorates explode with sulphur.*—Shake together some pieces of sulphur and crystals of chlorate of potass—no action takes place. Pound them in a mortar, and a loud snapping noise, attended by a flash of light, will announce their union.

47. *Chlorates explode with phosphorus.*—Triturate in a mortar, or strike upon an anvil, ½ a grain of phosphorus, previously mixed with 1 grain of chlorate of potass—the explosion which ensues will be very loud.

48. *Chlorate of potass explodes with arsenic.*—Place upon an anvil 2 grains of chlorate of potass and 2 grains of pulverized arsenic, and strike them smartly with a hammer; a very loud explosion, attended with a flash of light, will be the consequence. Here the intensity of heat occasions combustion of the metal.

49. *Iodates detonate with combustibles.*—When 8 grains of iodate of soda or potass, with 6 grains of sulphur, are struck upon an anvil, an explosion will take place.

50. Cut 3 grains of phosphorus very fine, and mix with it 6 grains of iodate of potass; wrap them up hastily in a piece of paper, place them on an anvil, and strike them smartly with a hammer; violent detonation will be the consequence.

Even compression, or a slight friction, will sometimes occasion rapid chemical changes, not unattended with danger, as we witness in the ordinary lucifer matches.

51. *Compression occasioning combustion.*—Cut a small piece of phosphorus of the size of a split pea; place near it, on a marble

slab, a small globule of potassium. Press heavily with the end of a table knife on the two substances together; vivid combustion will take place, and the two substances will unite, (forming by the assistance of oxygen from the atmosphere,) phosphate of potass.

52. Repeat the experiment; but instead of potassium use sodium. The pressure must be heavier; combustion will be the consequence, and phosphate of soda will be the product.

53. *Trituration causes liquifaction.*—Triturate together in a Wedgewood mortar, ½ an ounce of sulphate of soda, or else ½ an ounce of sulphate of zinc, with the same quantity of acetate of lead, (sugar of lead;) they will combine, and be rendered fluid.

54. Put ½ an ounce of sulphate of soda with the same quantity of nitrate of ammonia; no action will take place, but if they be smartly rubbed together in a mortar, they will both part with their water of crystallization, and this water will render them both quite fluid.

55. Put ½ an ounce of chloride of lime, with the same quantity of acetate of lead, in a mortar—triturate them together. These salts will part with their water of crystallization, and become fluid.

56. Triturate together ½ an ounce of chloride of lime, with the same quantity of nitrate of soda. These two substances will operate upon each other, and be rendered fluid.

57. Rub together in a mortar ½ an ounce of citric acid in crystals, with the same quantity of carbonate of potass; these substances will combine, and become fluid. The citric acid may be recovered by saturating the potass with sulphuric acid. Water poured over it will form solutions of citric acid and sulphate of potass, which will crystallize separately.

58. Put into a mortar 2 drams of pure lime, with 2 drams of oxalic acid. These substances by trituration will become fluid, from the water of crystallization contained in the oxalic acid, and from the heat they absorb in the act of combination.

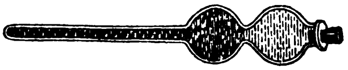
59. Put 3 drams of carbonate of ammonia, (sal ammoniac,) and 2 of sulphate of copper, into a mortar—triturate them smartly; they will become fluid, and of a violet color.

MIXTURE OR COMBINATION.

To call mixture a chemical operation may appear equally untrue and unnecessary. Untrue, because with bodies that have no chemical affinity with each other a mechanical effect only is produced; and unnecessary, because every chemical experiment is an instance. Even in many of those examples where light, heat, and electricity occasion chemical action, it will be found that a mixture takes place, although the young chemist is not able at all times to explain the nature of the mixture. The effect of mixing different bodies together is often very unexpected, sometimes producing heat, cold, combustion, fluidity, (as in *Ex.* 26. 53. 54,) &c. &c.

60. *Change of temperature and specific gravity.*—Mix together like measures of strong sulphuric acid and of water. The mixture will not only be less in quantity than the two separately, but the heat so great as to be above that of boiling water.

Note.—To show this in a satisfactory manner in a lecture room, it is customary to employ a tube with a double globe, (as figured below.) To use it, fill the stem, and one ball, with strong sulphuric acid, and the upper ball with water; cork it, and turn it upside down. The diminution of volumn when the water and acid are thus mixed together will be seen in the tube.



61. *Intense heat produced by mixture.*—Place a tea cup or gallipot, containing an ounce of water, on the hearth, and pour into it, (at arm's length, the hand being defended by a glove,) half an ounce of fluoric acid, from a leaden bottle. Sudden ebullition and most intense heat will be the consequence.

Note.—It is not advisable to touch the gallipot, as this acid is most corrosive, producing ulcers on the skin wherever it touches. If such an accident should unfortunately occur, with this or any other acid, the best, and indeed the only remedy is immediately to plunge the part into a vessel of cold water. Another precaution is necessary with this experiment; that is, to perform it in the open air, as the dense fumes arising from it are highly corrosive, particularly when they attack the internal surface of the nose.

62. If an ounce of sulphuric acid, of the temperature of 32°, be poured over an ounce of pounded ice, of a like temperature, the density of the combined substances will be greater than that of the two substances separately; and in this condensation so much latent caloric will be evolved, that the mixture will give out heat, almost equal to that of boiling water. The other strong acids produce like effects, when mixed in certain proportions with water, &c. &c.

63. *Cold produced by mixture.*—Pour 1 ounce of cold water upon 4 drams of chloride of ammonia, (sal ammoniac,) in powder, in

a 3 or 4-ounce phial. Cork it, and shake it well in the naked hand; as the water and salt combine by this agitation, a very great degree of cold will be felt.

64. If a piece of ice be put into a jar containing chlorine, it will liquify with astonishing quickness, and if the hand be placed on the jar very sensible cold will be felt, from the rapid absorption of caloric from the hand and surrounding bodies. This heat becomes latent in the liquifying ice.

65. Pulverize quickly in a mortar 1 ounce of ice, and pour over it in a tumbler 1 dram of sulphuric acid, previously cooled to 32°. Stir the mixture, and the whole will become fluid. If a thermometer be immersed, the temperature will be found very near 0°, or 32° below the freezing point. Here the action of the acid on the ice increases its volumn, and of course much caloric is absorbed from surrounding bodies, to be rendered latent in the new compound. In the immersion of the thermometer 32° of sensible caloric are absorbed from the liquid contained in it, that is, from the alcohol; and if the hand be applied very sensible cold will be felt, until the mixture has abstracted its full quantity of latent caloric. To reconcile this experiment with No. 62, it is to be observed, that here the quantity of acid is only sufficient to liquify the ice; there the quantity of acid being greater it acted as in *Ex*. 60.

Note.—For other experiments of this kind, see *Freezing Mixtures*.

66. Mix together some tin foil, and about a tenth part of its weight of mercury; they will unite, and form a metallic paste. This mixture is called ***Mineral Marmoretum***, and ***Succedaneum;*** and is used to fill decayed teeth. After being applied, the mercury gradually evaporates, leaving the tin in a lump, and which acts as a plug, and keeps the air from the nerve of the tooth.

67. Pour a little water upon a lump of fresh burnt lime; after a few minutes the lime will swell, break into pieces, and become a white fine powder. If lime be in the quantity of a bushel or two, so great a degree of heat will at the same time be extricated, that shavings and other combustible substances will be inflamed upon holding them to the lime.

68. Put some fresh burnt plaster of Paris in a basin; pour water upon it sufficient to make the whole of the consistence of cream. In a few minutes the paste will become more and more solid, until it acquires a consistency nearly as hard as stone—during its solidifying great heat is given out. Pouring the above liquid paste into previously-prepared moulds is the method of making plaster of Paris ornaments, gems, figures, &c., as will be explained hereafter.

69. *Combination of solids.*—Rub together very briskly in a mortar 1 ounce of sulphur, with the same quantity of potass. When properly combined, the color will be dark green, sulphuret of potass being formed. This substance should be kept in a well-stopped phial, as it is very liable to attract moisture from the atmosphere, by which sulphuretted hydrogen is formed—a gas of a most fetid and disagreeable odour.

70. Rub together in a mortar 2 drams of sulphur and 1 of mercury. The lustre of the one, and the yellow color of the other, will disappear, the whole being converted into a black powder, which is the black sulphuret of mercury, commonly called Ethiops mineral.

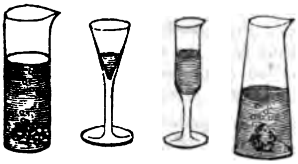
71. Let ¼ of an ounce of oil of turpentine be poured into a gallipot, and ¼ of an ounce of nitric acid, with 5 drops of sulphuric acid, into a phial tied to the end of a long stick. The acid on being thrown upon the oil will cause deflagration; abundance of light and heat being extricated. This experiment must be performed in the open air, and the phial held at arm's length when it is poured upon the oil.

72. Mix together chlorine gas and carburetted hydrogen gas; they will unite, and form an oily looking liquid.

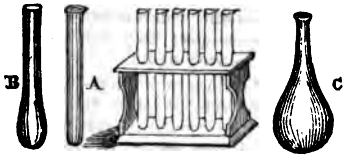
Note.—The union of chlorine and nitrogen forms the chloride of azote, the most explosive substance known; oxygen and hydrogen combined form water; oxygen and nitrogen combined form atmospheric air, nitric acid, &c., as hereafter explained.

SOLUTION, INFUSION, AND DIGESTION.

Dr. Faraday justly observes, that "there are two great and general objects to be gained by solution, which renders it a process of constant occurrence in the laboratory. The first is that of preparing substances for the exertion of chemical action; the second object is that of separating one substance from another; this being continually effected by the use of such fluids as have a solvent power over one or more of the substances present." Solution presents itself under three forms:—the solution of solids, liquids, and gases. The body in which any thing is dissolved is called the ***solvent***, or ***menstruum;*** the body dissolved is said to be ***soluble***, and is called a ***base;*** the mixture of the two is the ***solution***. When the solvent has taken up as much as is possible of the soluble matter, we call the result a saturated solution. The degree of solubility in bodies is extremely varied, as well as the menstrua used to dissolve them; so that one material may be soluble in alcohol, or in oil, and not in water; or it may be soluble in water, and scarcely in any thing else; or it may dissolve in numerous solvents, or in none. For performing solutions it is necessary to be provided with several small rods of glass, and some glasses. The following forms are usually given to solution glasses :—

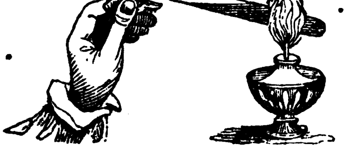


But any others, such as wine glasses, will answer for the purpose of experiments with small quantities of materials. Watch glasses are excellent, and so are test tubes, which are small tubes of glass from ¼ to ¾ of an inch in diameter, and from 2 to 6 inches in length. In London these, and other glass chemical apparatus, may be bought very cheap of the Italian barometer makers, who live in Leather Lane and its neighbourhood. Below are represented several test tubes of different sizes. Observe to choose them of very *thin* glass.



All these instruments are equally useful for evaporation and other chemical operations. Solution is usually much assisted by heat, pulverizing the base, and by trituration and stirring.

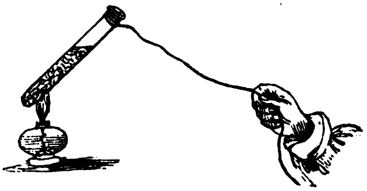
Ex. 73. *Solution of Solids.* — Dissolve some common salt in common cold water, in a large tube; and put so much salt that a portion of it remains at the bottom of the tube. Suffer it to settle; pour off the clear liquor into another tube, and boil it over a lamp. It will now deposit some more of the salt; thus proving that cold water will dissolve more of this particular kind of salt than hot water. The salt deposited during the heating of the liquid will be re-dissolved as it cools. To preserve the hand from the heat of the tube, and the vapour of the boiling liquid, the tube may be inserted in a large cork, or else supported by a wire as in *Ex.* 75, or held by a piece of paper twisted round it.



Note.—In dissolving the salt small bubbles will be seen to arise from it. These are not the result of a chemical action, but merely air bubbles which are liberated as the salt dissolves.

74. Dissolve some sulphate of copper in water, until you have a saturated cold solution, which you may know to be the case by some of the sulphate remaining undissolved at the bottom of the tube. Hold this over a lamp or the fire till it boils; during the heating it will take up more sulphate than it did before, the extra quantity being again deposited in cooling. This shows that bodies may be more soluble in hot than in cold water, and this is very generally the case. The instance of common table salt being most soluble in cold water is an exception to a general rule.

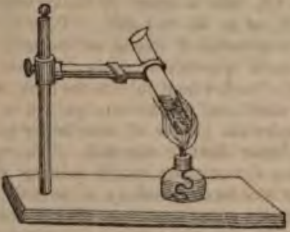
75. Dissolve 2 grains of copper in 12 drops of nitric acid, using a tube of the form below. Observe the effervescence that is produced, the production of red gas just above the liquor, the change of the liquor to green, the heat which is produced, and the peculiar smell that is disengaged. In one minute the copper will be all dissolved; the liquor remaining green. Blow air into the tube by a smaller tube held in the mouth. This expels the red gas, and turns the green liquor blue, alternately shake the tube, and blow air into it, until the green liquor and red gas no more return—the smell goes away with the gas. Look *into* the tube, and not *across* it, to see the color of the liquor and gas. Next, holding the tube by a wire twisted round it, thus, boil the liquor over a spirit lamp.



White fumes of nitric acid fly away. When the liquor gets thick and pasty, allow it to cool. It will form a mass of blue crystals, proceeding like rays from a centre; this is nitrate of copper. Apply heat as before; the crystals then melt, get drier, and stick about the sides of the glass as a hard cake. The salt now decomposes, and a strong smell of nitric acid is disengaged. When the bulb is cold, half fill it with water. Part of the hard matter dissolves, producing a blue solution of nitrate of copper; part remains undissolved as a blueish green powder. This is a nitrate of copper, with excess of base, which is insoluble in water. Add a drop or two of nitric acid, and the whole will dissolve.

76. Place a piece of iron at the bottom of a test tube, and pour strong sulphuric acid upon it; none, or very little appearance of solution will be evident. Dilute the acid with two or three times its weight of water; a very powerful action will immediately ensue, a salt will be formed, a gas will escape, and the iron be dissolved.

77. Instead of the iron in the last experiment, use a piece of silver, and pour upon it strong nitric acid, a slight action only is observable, but if the tube be heated until the liquid boils, a violent ebullition takes place and the silver is dissolved; nitrous gas escapes, which is known from its orange color and powerful odour—the liquid changing to a solution of nitrate of silver, or lunar caustic. As the rising fumes are excessively pungent and corrosive, a wooden and tin stand may be made for the test tube, as follows:—



78. Mix together equal quantities of sugar, starch, marble or chalk, and sand in a mortar. Take about an ounce of the mixture, and by means of cold water dissolve out the sugar; collect the washed residue, which need not be dried, and mixing it with water in a basin, heat it to boiling; the starch will now be dissolved, and by washing may be removed from the insoluble part. Now subject the remaining powder to the action of a little dilute hydrochloric acid, to dissolve the carbonate of lime or marble, and having removed the solution formed by washing, nothing but the sand will remain; a separation and imperfect analysis of the mixture will thus be made.

79. Boil a few fragments of gum mastic in a tube with alcohol under pressure, that is, closing the top of the tube with the finger, (the hand should be covered by a glove to prevent the heat of the tube from burning it, and to guard against the effects of the explosion should the tube burst.)

This solution diluted with more alcohol, so as to diminish the quantity of mastic to 70 grains in half a pint, forms an excellent wash for fixing chalk and pencil drawings.

80. *To make phosphoric oil.* — Dissolve 1 grain of phosphorus in a tea spoonful of olive oil in a test tube, by means of the heat of a water bath. The phosphorus will dissolve but slowly; when it is dissolved the liquid must be kept in a well-corked phial. A few drops of the oil rubbed over the face, hands, or clothes, will appear quite luminous in the dark; and so also will be the contents of the bottle itself when uncorked.

Note—A common glue pot is the most familiar instance of a water bath, and one may be used for numerous purposes of solution, slow evaporation, &c. For delicate purposes, like the above, a water bath may be made of a small test tube, inserted in a larger one—the latter being partly filled with water; and although oil, or other liquid, may be used instead of water in the outer tube, when a greater heat is required, yet it is still called a water bath. In thus making a water bath the outer tube should be the shorter of the two, that the steam may not interfere with the solution tube.

81. Instead of olive oil, as in the last experiment, use the oil of lavender, lemon, or any other essential oil. Set the tube, or it may be a phial, aside for a day or two, when the phosphorus will be dissolved. This substance having the property of readily dissolving in cold essential oils, or hot fixed oils, the liquid will have the properties of that in the last experiment.

82. Make a saturated solution of nitre (nitrate of potass or saltpetre) in cold water, and assist the rapidity of solution by trituration; this is done as follows:—Put the nitre in a mortar, pour upon it a little water, and rub them together with the pestle, breaking the nitre to pieces; then add more water, a little at a time, continuing to rub between

each addition of water; by this means a cold solution will be made in a very much shorter time than by any other method.

The solution of a liquid and of a gas, though terms sometimes used, are in themselves inappropriate; it is better to say the combination of liquids, and the absorption of gases. Some liquids combine readily without the admixture of a third body—as sulphuric acid and water were found to do in *Ex.* 60. Spirits of wine and water also are readily mixed, but a greasy liquid does not combine with the water unless its unctuous properties be destroyed by an alkali, as in *Ex.* 2; so also a fluid, though it may have some of the properties of a spirituous liquid is not miscible with water, if it have also a resinous character. So as to gases, certain of them are soluble in water, others not, and the law of their solution is that cold water will *take up*, or absorb more gas than hot water; gases themselves will sometimes dissolve other substances:—thus, hydrogen it will be seen hereafter will absorb zinc, arsenic, phosphorus, &c. The most usual and convenient solvent is water, the next best alcohol, then ether, and finally oils—metallic substances are dissolved in the acids. Sometimes the two former of these are mixed together as in *Ex.* 88. Some of the solutions of the acids, dissolve substances without altering their properties as in *Ex.* 89. Liquid ammonia is also sometimes used as a solvent, and the solutions of potass and soda frequently. " The alkaline earths are remarkably soluble in a solution of sugar, and also, though to a less degree in solutions of extract and other vegetable matters. Tartaric acid, or tartrates have an extraordinary power in making many metallic oxides soluble, which are not so by other acids without it, and still more in holding them in solution when such substances are added as in ordinary circumstances effect their separation."—*Faraday.* Animal and vegetable substances, as well as impure inorganic matters, often require to have certain portions of them dissolved away from the rest, it may sometimes be on account of the medicinal properties of the extract, or as a dyeing material, or to keep as a test, or for some other use. If hot water be merely poured upon the substance, the process is called *infusion;* when the heat is continued for some time by the application of fire *decoction;* and when it consists of pouring cold or warm water on the substance, and allowing it to stand for some time, it is called *maceration.* These several cases may be thus exemplified:—

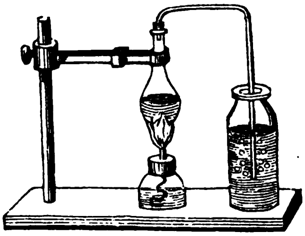
83. Mix together spirits of turpentine and water in a phial. No union will take place, however much they may be shaken together. Add linseed oil to this, the oil will unite with the turpentine, but not with the water.

84. *Soda water.*—Take a soda water bottle, and fit a cork to it, which have ready at hand. Pour into the bottle water, until it is about three parts full; then get ready a crystal of tartaric acid, and another of the carbonate of soda—each about the size of a small hazel nut. Drop these both together into the bottle, and cork it immediately—tyeing down the cork. The two substances will dissolve, decompose each other, carbonic acid will rise, and be absorbed by the water. After remaining some time, and shaking the bottle, it may be uncorked, and the liquid drank—it is soda water. It is only a certain portion of the gas which has been taken up by the water. The rest escapes suddenly, as is well known.

85. Ginger beer may be made in the same manner, flavoring the water previously with ginger and sugar.

86. Take the soda water just made; put it into a Florence flask, heat it by holding it over a lamp, and the gas in the water will escape as the flask becomes hot.

87. *Solution of sulphuretted hydrogen.*—Put ½ an ounce of sulphuret of potass, made by *Ex.* 69, into a retort or flask, with a tube to it, as is shown below. Pour upon this a tea spoonful of strong sulphuric acid, with an equal quantity of water. Fasten by means of a cork a bent tube to the flask, and let the other end of the tube pass 2 or 3 inches under the surface of some water in a phial. Apply heat to the flask, a gas will arise from the mixture, which passing into the water will be absorbed by it, as will be known by the water retaining, after the conclusion of the experiment, a most fetid smell. It is now a solution of sulphuretted hydrogen, and may be corked and kept for use as a test for the metals.



88.—Mix together chloride of sodium, (common salt,) and sulphate of lime, (plaster of Paris,) and afterwards separate them by solution. Water is the best solvent for the salt, but it will also dissolve a small portion of the plaster. Use therefore a solvent of 1 part of alcohol, and 2 or 3 of water. This will dissolve only the muriate, and leave the sulphate untouched; thus they may be separated from each other.

89.—Cut some Indian rubber in small pieces; put it into some hot acetic acid, and it will dissolve, though its properties remain unaltered.

90. Put some sulphate of lead in a watch glass, and pour over it a few drops of dilute hydrochloric acid. Warm the glass, and the sulphate will dissolve; heat it still more, and the hydrochloric acid will be driven off, and only sulphate of lead remain, as at first.

91. Place a little of the solution of any salt of silver, such, for example, as the nitrate, in a test tube. Add to this some potass; a powder will be thrown down. Pour off the liquid, and add liquid ammonia, (spirits of hartshorn.) The ammonia will dissolve the powder, which is the oxyde of copper.

92. Dissolve quick lime in water, in a vessel; evaporate a certain portion of the solution to dryness, and note the quantity of lime left. Then make a similar solution of lime in another similar vessel, with water containing one half its weight of white sugar. Take the same volumn of this solution as before, evaporate to dryness, and burn off the sugar in a crucible. Ascertain the weight of lime left, and observe how much it surpasses the former quantity; or, in other words, how much the sugar has increased the solubility of the lime.

93. *Colors for chemists' windows.*—*Green*, dissolve verdigris in water, and add a little vinegar. *Blue*, (see *Ex*. 28,) or else dissolve Prussian blue. *Red*, boil a few grains of cochineal in water. *Yellow*, boil in water either quercitron bark, or else dissolve Indian yellow, or what is better, saffron boiled in the same way, till the color is obtained. *Pink*, dissolve rouge, or what is the same thing the color from a pink saucer. *Purple*, to the red liquid before mentioned, add a little Prussian blue. *Straw-color*, gamboge dissolved in water.

94. Take a little of the dye drug, called Carthamus tinctorius, or safflower; pour water upon it, and let it digest or remain some time. The water will become yellow, that is, it will extract a *yellow* coloring matter—pouring this away, put fresh water to the same safflower, and add carbonate of soda. This alkaline liquid will dissolve a *red* coloring matter, showing that the red and yellow are of different natures—one soluble in water, the other in an alkali.

95. *Colored inks.*—Dissolve in water any of the usual water colors, particularly the transparent ones, gamboge, Indian yellow, sap green, Prussian blue, indigo, burnt Sienna, verdigris, &c., and add a little gum water to the solution. A mixture of any of the above will of course vary the color.

96. *Infusion of galls.*—Make a strong infusion of bruised nut galls, and set it aside in covered jars for a month or two, at the end of that time a quantity of crystalline matter will be observed at the bottom of the fluid, which may be collected. It is nearly pure gallic acid—the above infusion is to be kept, it is often wanted.

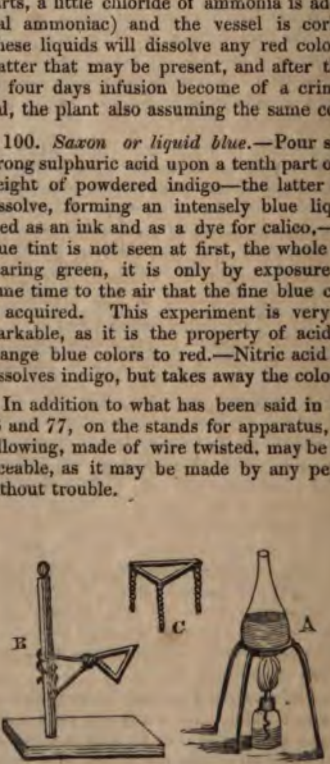
97. *Infusion of turmeric.*—Soak for an hour, some powdered turmeric in hot water, pour the water off clear from the sediment and keep it for use, it is a test for alkalis.

98. *A test for acids.*—Make an infusion of red cabbage, or of the petals of the blue violet, or of the blue Iris, or indeed of any blue flower; strain it clear, add a little spirits of wine to it and keep it for use, as a test for acids.

99. *To try if a plant contains a red coloring matter.*—A little of the plant is to be put into a glass vessel; it is to be moistened with ammonia and lime water in equal parts, a little chloride of ammonia is added, (sal ammoniac) and the vessel is corked. These liquids will dissolve any red coloring matter that may be present, and after three or four days infusion become of a crimson red, the plant also assuming the same color.

100. *Saxon or liquid blue.*—Pour some strong sulphuric acid upon a tenth part of its weight of powdered indigo—the latter will dissolve, forming an intensely blue liquid, used as an ink and as a dye for calico,—the blue tint is not seen at first, the whole appearing green, it is only by exposure for some time to the air that the fine blue color is acquired. This experiment is very remarkable, as it is the property of acids to change blue colors to red.—Nitric acid also dissolves indigo, but takes away the color.

In addition to what has been said in *Ex*. 73 and 77, on the stands for apparatus, the following, made of wire twisted, may be serviceable, as it may be made by any person without trouble.



PRECIPITATION AND FILTRATION.

These are processes of constant recurrence with the chemist. The first may be considered the contrary to solution, for a precipitate is a solid matter, which has been dissolved, but which is no longer so; it therefore rises to the top of the liquid, or falls to the bottom of it, according as its specific gravity may be more or less than water. If the liquid above the precipitate be wanted, it is decanted or carefully poured off, as wine is from its crust or dregs. If both are wanted it is usual to filter the whole; the liquid passes through the filter; the precipitate remains in the filter. In this case the solid still retains some of the solution among its mass. To separate this, washing or lixiviation, is had recourse to; this is done either by pouring some of the solvent, water, spirit, or whatever else it may be, over the precipitate in the filter, or still better drying the precipitate, and afterwards mixing it with the solvent, and filtering a second time. The vessels used for precipitation are the same as solution glasses and test tubes. Precipitates are occasioned by means of a third body added to a solution, of such a nature as to alter the relation of the solvent to the substance it holds in solution; sometimes no change takes place in the nature of the matter dissolved; at other times it is chemically altered by the second mixture. Some precipitations take place instantly, others only after a length of time, some only when assisted by heat, others by the agency of light.

Dr. Faraday offers the following advice on making of precipitations. He says—"It is frequently necessary to add a precipitant to a solution, until no further effect is produced. Upon commencing the addition, it is easy to observe the formation of the precipitate; but when the solution becomes milky or thick, the student is unable to perceive whether the additions he makes actually cause increased separation, or whether they are useless. As soon as this happens, it is better to desist from adding the precipitant, and after stirring the whole, so as to mix it thoroughly, to allow it to stand a few minutes; a separation of the precipitant will take place at the surface, and allow the removal of a small portion of the clear fluid into a clean glass. A small quantity of the precipitant being added to this, notice is taken whether any precipitation takes place; if not, enough has been added to the larger portion—but if a further effect takes place, the portion removed is to be restored, more of the precipitant to be added, and the whole again stirred up and examined as before, until it has been in this way ascertained that no further addition will produce any precipitation." This great care is not always necessary, yet sometimes were it not taken, the precipitant would be re-dissolved in the liquid. Thus it is in *Ex*. 28, where the oxyde of copper is first precipitated from the sulphate by ammonia, and afterwards re-dissolved when the ammonia is in excess, so that the fine blue color is occasioned by ammoniuret of copper.

Ex. 101. Add water to a solution of camphor in spirits of wine; the camphor will be separated in the state of a white powder, which, if there be much water, will float upon the liquid.

102. Add a solution of sugar of lead to gum water; the gum will separate also in a white powder, which will sink to the bottom of the vessel.

103. Add to a solution of chloride of barytes, a few drops of sulphuric acid. This will decompose the salt, and a sulphate of barytes will be thrown down as a white powder.

104. *To precipitate Prussian blue.*—Take a small portion of a solution of sulphate of iron, (green vitriol,) and precipitate the iron by adding to it ferro-prussiate of potass. A blue precipitate will be obtained, which is to be repeatedly washed; this is Prussian blue. As long as much of the soluble matter remains, the washing water and the precipitant will easily separate; but as the washing approaches completion, it will be found that the pure water added dissolves the blue precipitate. Remark this effect, and then add a little pure hydrochloric acid; this will immediately cause as complete a separation of the Prussian blue as before, and the washing fluid will become nearly colorless.

105. Take a solution of any salt of zinc; such, for example, as the sulphate, (white vitriol,) and add a few drops of the solution of ferro-prussiate of potass; the precipitate will be a white powder.

106. Instead of a salt of zinc, use a salt of copper, as blue stone. This, with the same precipitant, will throw down a reddish brown powder.

107. Place before you an open vessel, full of clear lime water. Hold a glass tube to the mouth, and inserting the other end under the surface of the lime water, blow through the tube for a few seconds. The lime water will become turbid or cloudy. The air from the lungs, containing carbonic acid gas, combines with the lime, forming the carbonate of lime or chalk, which falling to the bottom of the vessel occasions its turbidness.

108. *To prepare oxyde of cobalt.*—Put a dram of nitrate of cobalt into a small phial, containing an ounce of a solution of pure potass. The oxyde of cobalt will be precipitated of a blue color. If the phial be now

corked, the blue color disappears, and a lilac one will succeed it. This will afterwards become lighter, or of a peach blossom hue; a light red color will finish the number of changes.

109. *Decomposition of milk.*—If an ounce of alcohol is poured into half a pint of milk, the latter will be decomposed, and a copious white precipitate will fall down. Here the alcohol combining with the water, the albumen and oil fall down in the state of curd.

110. *Preparation of pearl white.*—Pour some distilled water into a solution of nitrate of bismuth as long as precipitation takes place; pour off the liquid resting above the precipitate, and dry the latter by a gentle heat. It will be a beautiful white powder, known by the name of *pearl white*, and much used as a cosmetic.

111. *Scheele's green, to make.*—To a solution of nitrate of copper, add a solution of arseniate of potass. The fluid will be of a beautiful intense green color, having an abundant precipitate of arseniate of copper, or Scheele's green, a beautiful pigment, known otherwise by the name of emerald green.

112. *Chrome yellow, how made.*—To a solution of acetate of lead, (sugar of lead,) add a solution of chromate of potass, as long as precipitation takes place. In experiments where there are two salts used a double decomposition takes place; in the present case acetate of potass is held in solution, and chromate of lead is precipitated. This salt is of a beautiful orange or yellow color, and is known by the name of chrome yellow.

Let it be remarked, that in performing experiments of this nature, the color that solutions and precipitations appear to have in daylight is always understood, as it is impossible to detect numerous colors by artificial light. This is very necessary for the chemical lecturer to observe, if he have occasion to lecture in the evening, that he may so choose his experiments as to leave no doubt upon the minds of his auditors. Experiments of this kind may be varied by using them as

113. *Sympathetic inks.*—Dissolve both the salts, mentioned in the last experiment, in water; wash one side of a sheet of paper with one of the solutions, say the sugar of lead. Let it dry, then taking a new pen, write upon the prepared paper with the other, the chromate of potass; a yellow color will follow the pen, while the rest of the paper will remain white. In this manner *Ex.* 104, 106, 111, 112, and numerous others, may be varied. The following colors are produced by the salts mentioned beneath, using them in the above-described manner:—

114. *Carmine.*—Chromate of potass and nitrate of silver.

115. *Crimson.*—Chromate of potass and nitrate of mercury.

116. *Lemon.*—Chromate of potass and nitrate of bismuth.

117. *Blue.*—Prussiate of potass and carbonate of iron.

118. *Purple or black.*—Solution of galls and sulphate of iron.

119. *Preparation of rouge and pink saucers.*—Add to the red or alkaline solution of carthamus, (made by *Ex.* 98,) lemon juice. Let it rest some days; then pour off the liquid which floats above the pink powder. This powder is added to a small quantity of soap, and put into small saucers, where it becomes dry, It is used in dyeing silk, &c., flesh color. Rouge is the same precipitate, mixed with extremely fine powder of talc, or rather of fine powder of soap stone, commonly called French chalk.

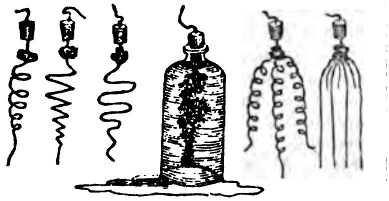
120. *Plating iron with copper.*—Make a solution of sulphate of copper, and in it place a clean iron knife. This will soon become covered with a complete coat of copper, appearing as if it had been changed into that metal. A great portion of the scraps of tinned iron, broken cast-iron vessels, &c., sold as useless in London, is carried and thrown into certain streams in Scotland and Wales, the waters of which are impregnated with copper. Here lying a considerable time they abstract the copper; at the same time the iron itself is dissolved. The metallic mass, which is afterwards taken up, is therefore entirely copper.

121. *Precipitation of mercury.*—Dip the end of a clean brass or copper wire into a solution of nitrate of mercury. The wire will become beautifully coated with that metal. In this manner wires are tipped with mercury, when required to form a true metallic contact in electro-magnetic experiments.

122. *Plating zinc with copper.*—Into a wine glass, nearly filled with distilled water, put 10 grains of powdered sulphate of copper and 2 drops of nitric acid. Stir the whole with a glass rod until the salt be dissolved; then immerse a rod of zinc. The copper will be immediately precipitated upon the rod in the metallic form.

123. *The lead tree, commonly called the zinc tree.*—Put ½ an ounce of sugar of lead, in powder, into a clean glass globe, wine decanter, or large phial, filled with water. Add 10 drops of nitric acid, or a little vinegar, and shake the mixture well. Then take a small piece of zinc, about the size of a hazel nut, tie it to a string which passes through a cork that fits the phial; twist once or twice round the zinc a piece of fine brass or copper wire, and let the end of the wire depend from it in

any agreeable form. Place the zinc and wire, thus prepared, so that it shall hang as near as possible in the axis of the bottle, and that no part shall touch either the top, bottom, or sides of it. Let the whole rest quietly for a short time, metallic lead will soon deposit itself on the zinc, and along the wire, forming a brilliant illustration of chemical affinity. The zinc having a greater affinity for the acetic acid, which forms part of the sugar of lead, than the lead with which it is combined has, unites with it, and suffers the lead to be deposited. The liquid will change to the acetate of zinc. The use of the nitric acid is to dissolve a white cloudy precipitate, often formed when sugar of lead is dissolved in common water, or if it contain of itself any impurity. Filtering will also remove the cloudiness.



124. *The tin tree.*—Into a vessel similar to that used in the last experiment, pour distilled water as before, and put in 3 drams of muriate of tin and 10 drops of nitric acid, and shake the vessel until the salt is completely dissolved. Suspend a piece of zinc as before, and the metal will in like manner be precipitated,—appearing similar to the lead tree, but having more lustre. These two experiments and others similar to them, are in reality galvanic, and show the power of electricity in producing chemical action.

125. *The silver tree, or Arbor Dianæ.*—Pour into a glass globe or decanter, ¼ of an ounce of nitrate of silver, dissolved in a pint or more of distilled water, and lay the vessel on the chimney piece, or in some place where it may not be disturbed. Now pour in ¼ of an ounce of mercury; in a short time the silver will be precipitated in the most beautiful arborescent form, resembling real vegetation; this has been generally termed the Arbor Dianæ, or Tree of Diana.

126. *Ditto, by another method.*—Pour into a diluted solution of the nitrate of silver as above:—1 dram of nitrate of mercury, dissolved in 2 drams of water.

127. *Ditto, by a third method.*—Dissolve 6 drams of nitrate of silver, and 4 drams of nitrate of mercury in a decanter of distilled water; and dropping into it 6 drams of an amalgam of silver, composed of 3 drams of mercury, and 1 of silver. This plan is considered the best, but it is rather too expensive.

128. *Precipitation of bismuth.*—If a copper rod be immersed in a solution of 20 drops of nitrate of bismuth, in a wine glassfull of water, it will soon be covered with a beautiful precipitate of that metal.

129. *Precipitation of silver on copper.*—Dissolve 10 grains of nitrate of silver in a wine glassful of water, and immerse a clean slip or rod of copper; a beautiful metallic precipitate will immediately begin to take place upon it. The silver will be seen as it were to dart into the crystalline form.

130. *Another silver tree.*—A very pleasing variation of the last experiment may be made as follows:—Dissolve 15 grains of nitrate of silver in ½ a dram of water, and pour some of the mixture on a piece of clean window glass; bring the copper rod just in contact with the solution, and let the whole remain undisturbed for about three or four hours. At the end of that time a beautiful, white, metallic, crystalline precipitate, will have taken place on the glass, in that spot where the rod has touched the solution. If the rod, or copper wire, be bent and employed for the same purpose, the precipitation will take place on all parts of the glass, where this metal comes in contact with the fluid.

131. A still more beautiful effect takes place when several drops of nitrate of silver are let fall on a plate of polished copper. Here in a very short time a brilliant precipitation of metallic silver will take place, in an arborescent form. The causes of all these phenomena are the affinity which copper has for nitric acid, its abstraction of it from other bodies which have less affinity for it, and the consequent precipitation of the uncombined metal in a crystalline state.

132. *Silvering clock faces, barometer plates, &c.*—Mix together equal parts of muriate of silver, and moistened cream of tartar; with this rub the plate to be silvered, until the whole has acquired a complete coat, sufficient to preserve it from corrosion. During the operation it may be frequently heated, and immersed in distilled water to wash away the superfluous saline matter.

133. *Silvering plates for the Daguerreotype.*—Precipitate oxyde of silver from the nitrate by potass; filter, wash, and dry it. Dissolve this oxyde in pure liquid ammonia, the solution will be of a yellow color. Immerse a slip of polished copper in it, and let the moisture evaporate. When the copper is quite dry, hold it over a charcoal fire; the oxyde will be decomposed, and the metal reduced on the copper in the form of a complete coating. This may be made beautifully bright by polishing with leather. It offers a

much more brilliant and smooth surface than that of the last experiment, and is a ready method of silvering copper-plates for the Daguerreotype pictures.

134. *Silvering ivory.*—Prepare a diluted solution of nitrate of silver, and immerse in it an ivory paper knife; when the ivory has become yellow in that part where it is in contact with the fluid, take it out and immerse it in an ale glass, containing distilled water; place in a window, in a short time by exposure to the rays of the sun, it will become intensely black. Take it out of the water, and having wiped it dry, rub it with a piece of leather. The silver will now appear on the ivory in a metallic state.—*Mackenzie.*

135. *Precipitation of tellurium.*—When an iron rod is dipped in a solution of the chloride or other salt of tellurium, that metal will be precipitated on it in the form of a black powder, which, by friction, will soon exhibit a metallic lustre.

136. *To plate brass, &c., with platina.*—Dip a clean polished brass-plate into an ethereal solution of platinum; it will, when withdrawn, be covered with a beautiful silvery white coating of platinum, very durable and difficult to be rubbed off. In this way, polished brass door plates, the copper plates of certain galvanic batteries, also handles, knockers, and other articles, may be very economically covered with a coating, which is sure to preserve them from the action of the atmosphere, &c. When immersion is inconvenient, a rag may be dipped in the solution and passed over them.

137. *Gilding iron.*—If a bright or well polished iron rod be immersed in a solution of nitro-muriate of gold, the gold will be precipitated on it in a metallic state.

138. *Tinning pins and tacks.*—Fill a tinned copper vessel with alternate layers of brass pins, and plates or pieces of tin. Now pour over the whole a saturated solution of cream of tartar in hot water, so that the whole of the contents may be completely covered with the solution. Now place the vessel upon the fire, and let the liquid boil for five or six hours; when cold, the pins will be completely coated by the tin, which being dissolved by the salt is precipitated on the brass.

More on *gilding, silvering, plating, &c.,* hereafter.

FILTERING.

The art of filtering is constantly had recourse to by the chemist, as well as used for domestic purposes. Filters for the latter object are innumerable; their use is generally to purify the liquid, whatever it may be, without regarding the precipitate, but the chemist often requires that both should be preserved. Sometimes, indeed, it is only the clear solution that is required; at other times the precipitate only. Hence care must be taken with this operation, as well as with all others, however simple and obvious they may appear.

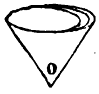
Filters are made of unsized, commonly called blotting paper, cloth, flannel, tow, sponge, raw cotton, sand, charcoal, gravel, porous stones, earthenware, &c. The first is, however, that most used in the laboratory. The filters, if very small, may be supported by the glass itself, or by a glass hoop placed over the vessel, as in the following cut:—

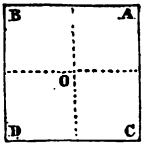
Or it may be rested in a funnel, suspended in the glass; or, still better, supported over it on one of the rings of a retort stand, as may be seen beneath:—

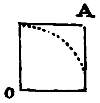
If a flannel filtering bag is used, it is generally tied to a hoop, and suspended by a string.

Slow filtrations of alcoholic tinctures and solutions should be covered over with a saucer or basin. Many substances may be filtered hot but not cold,—cocoa-nut oil for example.

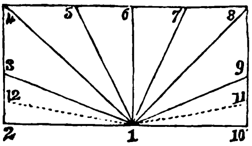
Ex. 139. *To make a common filter.*—Take a piece of clean, thin blotting paper, about 3 inches square, fold it in half, so as to bring the corners C D upon A B; then fold it again so as to bring the four corners together at A; cut off the corners so as to form a quadrant, in the manner shown by the dotted lines in the figure A O; and finally open the first fold, by separating the quadrant B from the other three quadrants, so as to produce an inverted cone like O. The letter O points out the position of the centre of the paper in all the figures.



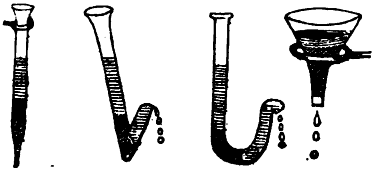




140. *To make a ribbed filter.*—Take a square piece of paper, and fold it in two as before; then make the folds shown in the annexed diagram, and let them all bend on the same side of the paper. Then make a fold between each of the above folds, so as to rise on the other side of the paper. When folded up it looks like a child's fan. Cut off the projecting corners, so that each fold may be of the same length. Gently separate the two sides of the filter, and form with it a little cup; put your finger into the cup, and gently push the bottom till it is round. In rubbing down the folds do not rub them near the centre of the paper, for fear of making a hole; this filter is used when the solution only is wanted. If the precipitate be required, the former kind is to be preferred, because of its being smoother, so that there are no corners in which the powder can rest. A ribbed filter is more rapid than a plain one.

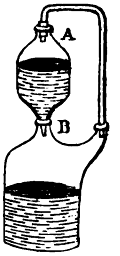


141. *To make a tube filter.*—Procure a glass tube, of a bent form, as shown beneath. According to the nature of the substance to be purified, so must be the nature of the filtering material. It may be filled with a piece of sponge, with raw cotton, (wadding,) with hemp, or other loose fibrous materials, or various powders, sand, &c. One of powdered charcoal may be made thus:—Put into the tube enough charcoal to fill the bend at the bottom, and to rise an inch in each of the legs of the tube, then press into each leg, upon the charcoal, a small piece of tow; this is merely to prevent the charcoal being disturbed when the liquid is poured in or out.



142. *To make a powder filter.*—Press gently into the tube of a glass funnel a piece of tow or cotton. Put upon the tow the powder; it may be charcoal, sand, glass dust, (for acids,) or other material, to the depth of 1 or 2 inches. Lay a coarse powder over all, to prevent disturbance. In these two last filters, it is needless to say that the precipitate is disregarded.

143. *To filter without contact with the air.*—A most valuable filter for this purpose was invented by Mr. Donovan. It consists of two glass vessels, connected by a tube, made air-tight by perforated corks at the junctions A and B. The upper vessel terminates in a conical pipe, ground into the lower one. The pipe of the upper vessel is first clogged with tow or cotton, the liquid poured in, and then the side tube annexed. The use of this tube is, that the air, as it is driven out of the lower vessel when this becomes filled with liquid, may issue into the upper vessel, now otherwise partly empty.



144. *Separating oil from water.*—Mix up equal quantities of oil and water, separate these bodies one from the other by filtration of the water through a filter, which has been previously wetted with water, such being necessary whenever two liquids are thus separated by filtration.

145. Make a filter of the powder of animal charcoal, cork up the delivering orifice, pour in some hot port wine, and let it rest some hours, then suffer the filtered wine to issue, observe its color, which will be very much paler than when put in.

146. Filter fresh made lime water by means of Donovan's filter. Using this filter prevents the access of the atmosphere, and therefore prevents the absorption of carbonic gas from it, which would make the lime water turbid. Any paper filter may remove the turbidity if formed in the lime water previous to its passing through the filter; but if left in an open vessel afterwards, the effect would then be without remedy. Chloride of lime and solutions of the pure fixed alkalis should be filtered by this method, the latter particularly because the new combination formed with the carbonic acid of the air will not be retained by the filter, as in the case of the lime.

Note.—In filtering any thick substance, wet the filter first, with some of the solvent, be it water, alcohol, &c.

EVAPORATION AND DISTILLATION.

These operations are other means of separating and purifying solutions. Evaporation consists merely of subjecting a solution to such a degree of heat, as will enable it to part with the whole or a portion of its moisture, thereby enabling solutions of metallic and other salts to crystallize, decoctions to become thicker and more concentrated, precipitates to lose their adherent moisture, and to become dry. In each instance these various preparations become not merely stronger and better adapted for numerous purposes to which it is necessary to apply them, but also are more easily and more conveniently kept. In subjecting a substance to evaporation, no notice is ordinarily taken of the vapor which flies off. If the liquid is to be preserved, the process is called *distillation*. The latter is conducted in close vessels, with some contrivance annexed to them, for condensing the steam which rises, and retaining the liquid which flows from it; or if the matter which flies off be gaseous, and, therefore not condensible; it is collected in proper receptacles, being purified by its passage through water or not as the particular case may require. Sometimes a solid substance may rise in fumes, and these condense again into a similar solid when cold; this process is called *sublimation*, and is had recourse to during the purification of many solids.

The proper heat to be applied in these various arts is extremely varied; so very different is the degree of temperature at which different bodies become vaporized. Hence, also, the necessity of great variety of apparatus. The principal, however, are retorts, receivers, and lamps. Two or three cautions are to be observed in using these. Suppose lumps of any thing are to be put into a retort, the retort must be held in a slanting position, with the bulb of the retort held *upwards*. If this be not attended to, it will, in all probability, be broken by the fall of the lumps. In distilling two liquids of different densities, such as spirit and water, sulphuric acid and water, ether and acid, &c., the ebullition or boiling will be very irregular, particularly at the beginning of the process. To avoid this, there should be placed in the retort some particles of a solid, which is not acted upon by the liquid contents; for example, platinum foil, brass wire, charcoal in lump, small pieces of glass, &c. Never fill a retort, or still, above three-fourths of its capacity; thus if it will hold 2 quarts, you must not attempt to distil more than 3 pints at a time. Watch carefully the moment of boiling, lest it should boil over, and the contents be lost. Always keep the receiver as cold as possible, by surrounding it with water, with ice, or with a freezing mixture. Sometimes, as will be seen in the experiments, the top or stem of the retort is made cold by means of wet paper, cloths, tubes of water, &c.; and in the ordinary purposes of distillation, the mouth of the still is annexed to a *worm*, (which is a twisted tube of metal,) and the worm is surrounded by water in a tub, called therefore a worm-tub. Take care that the joints of the distillatory apparatus are kept perfectly tight, that vapors may not escape. This is done by means of a *lute* or cement, made according to the nature of the liquid to be distilled. In evaporation, the top of the vessel should be fully exposed to the air. It may be carried on in a watch glass, a common test tube, saucer, or basin, or indeed any open vessel; though dishes, called evaporating dishes, of Wedgewood ware, are made and sold for the express purpose. Their form is given beneath, and their size varies from 1½ inch diameter to several inches; the smaller being nearly hemispherical, the larger proportionably more flat.

The position of the usual retort, manner of heating it, connecting it with the receiver, and cooling the latter by immersing it in a saucer of water, may be seen by the following cut. To the receiver is also attached a tube, sometimes necessary to ensure the safety of the apparatus, or to be used when a vapor is to be retained, which it will be if properly condensed, and yet a gaseous matter fly off.

The heat to be applied and manner of applying it must always be carefully attended to. To distil and evaporate some substances, the ordinary temperature of the atmosphere is sufficient; for example, sulphurous acid; others are assisted by a current of hot air, by a water bath, a vapor bath, a sand bath, by the heat of a lamp, or by the strong heat of a furnace. A water bath for evaporation may be very easily made, as was shown in *Ex.*80. Annexed are two of easy construction, one of them is merely a saucepan, with three holes made through the lid of it, three flasks are placed within side, their bottoms resting on the bottom of the saucepan, and their necks brought through the holes in the lid.

If the saucepan be partly filled with water, and placed upon the fire, the heat communicated to the flasks will evaporate the watery particles of their contents. The other contrivance is a vapor or steam bath, invented by Dr. Ure. In consists of a tin box, about 18 inches long, by 12 broad and 6 deep, a pipe from the bottom of it fits the mouth of a tea kettle; the top of the box has a number of circular holes cut in it of different diameters, into which evaporating dishes, flasks, &c. may be placed. When the nozzle of the kettle is stopped, the joints luted, the kettle partly filled with water, and placed on a common fire, steam will rise and heat the flasks or other vessels.

When a greater heat than that which water will give is required, the water may have salt mixed with it, making brine, which does not boil till it has acquired a heat of 228°, which is 16° above that of boiling water.

Any degree of heat whatever from that of the atmosphere to a red heat, may be procured from sand, and from the frequent use of such a medium, it should not be neglected for the ordinary purposes of the experimental chemist; sand baths, adapted for a small furnace, are made like a hemispherical cup, with a rim around the top to hang by; several of these cups or baths are usually sold together, and fit into each other; but such are not necessary, one being quite sufficient. An iron saucepan, filled with sand, and put over a common fire, answers every purpose. Below are seen a nest of sand baths, together with one in section. They are usually made of black lead and clay.

When a furnace is required, as it is for numerous operations, the cheapest and one of the best is that of Dr. Faraday. It is made of what is called a *blue pot* or crucible; this may be bought of Mr. Foster, 2, St. John's Square, Clerkenwell—one, 12 inches high and 7 inches diameter at the top, which is the proper size, costing 16*d*. To make this into a furnace, have rows of holes bored in it, as represented in the cut A, and bind it round with iron wire, at three or four different distances up it. Make two handles, one on each side, also of wire. Between the two lowest rows of holes rests within-side a sheet of iron, also pierced with holes; or else made with slight bars, as in the cut at C. A greater draught, and consequently a greater heat, is obtained by covering over the furnace with a portion of another blue pot, as shown at B; the size being such that it just fits into the lower one, or furnace. It is convenient also to have a tin or iron hood, with a pipe, 12 or 18 inches long, attached to it as at D, to fit on to the furnace occasionally. One or two grooves are cut in the upper edge of the furnace, in order that the beak of a retort may lodge in one of them, and be kept steady, and suffer the hood to be put on.

The account of the ordinary stills, used for the manufacture of spirits, &c., will be deferred for the present.

Ex. 147. *Evaporation produces cold.*—Wrap a linen rag round a test tube containing water, and moisten the rag frequently with sulphuric ether; when this has been repeated several times, without interruption, the water will be frozen.

148. Sulphuret of carbon is the most volatile substance known; if it be used instead of the ether of the last experiment, the water in the tube will be frozen yet more rapidly.

149. *To freeze sulphuric acid.*—Half fill a test tube with sulphuric acid, and surround it with a rag moistened by sulphuret of carbon, and the acid will speedily be frozen.

150. *Cooling wines, apartments, &c., by evaporation.*—Wines may be cooled by wrapping wet cloths around the bottles, and placing them in the sun or before the fire, that evaporation may be promoted. Wine and butter coolers act upon the same principle, for the vessels into which the bottles are put are made of a spongy or porous ware, through which the water exudes. The floors in the houses of the hot Asiatic countries are sprinkled with aromatic liquids, and wet cloths are fastened to the windows, that evaporation may take place, and the apartments be proportionably cooled.

151. Concentrate alum water by evaporation, so as to procure the alum it contains, partly in crystals and partly in a fine white powder. Put the water or solution in an earthern pipkin, boil it on the fire till a thin skin appears on the surface, then set it aside; as it cools, a great portion of the alum will be deposited in a crystallized form; collect as much of this as is required; if not enough, repeat the boiling and cooling as before; if too much, return the surplus to the pipkin and place it again on the fire, and then let all the moisture boil away. The crystals will next melt, and the water which they retain, called their water of crystallization, will be dissipated, the alum assuming the form of a light friable mass, which crumbled between the fingers forms a white powder, commonly called burnt alum; water added will again form it into crystals or a solution, according to the quantity used. Solutions of most of the salts may be evaporated in this way, but they cannot all be heated to the same extent, as the effect of the fire upon the crystals is very different, and some salts will decrepitate or fly about in small pieces.

152. *Preparation of sap green.*—Make a strong solution or extract, from the unripe berries of a shrub called Rhamnus tinctorius —or from any other plant which yields a green juice, such as unripe blackberries; inspissate this extract by evaporation at a very low heat like that produced by a water bath or steam bath. When the liquid has become thick as treacle, pour it into a mould, and expose it to the heat of the sun or of a slow oven; the rest of the watery particles will slowly evaporate and leave a cake of sap green. With other plants, lakes, madders, carmines, Indian yellows, &c., may be produced in the same manner. It must be observed, that it is not all vegetable colors that are thus useful, as many of them lose their color almost immediately after they are used, this is the case with litmus, saffron, safflower, &c.

153. *Lutes for joining distillatory apparatus.*—1. Flour and whitening equal parts, $\frac{1}{10}$ its quantity of salt, and water to make it into a paste. This is used by the distillers of spirituous liquors—2. Glazier's putty made of linseed oil and whitening. This is useful in distilling acids.—3. Fine pounded glass and the white of an egg is very secure for small articles.—4. Equal parts of muriate of ammonia (sal ammoniac) and whitening mixed into a paste with water, forms a very secure lute.—5. Common clay, with or without sand, and mixed with whitening and water, is a lute which will stand a great heat.—6. Linseed meal made into a paste with cold water is good for ordinary purposes.—7. To cover vessels which are to be submitted to an intense heat, nothing is so good as Stourbridge clay mixed with water.—8. *Fat lute* is very similar to No. 2; it is made of dried pipe clay and linseed oil, it is not acted upon by corrosive fumes.—9. Beat equal portions of water and the white of an egg, and add powdered lime, till of a thickness convenient for use; beat them well together. This will set very hard, and is adapted to cement together various chemical articles permanently; glue or blood may be used with lime instead of egg.

154. Distil half a pint of wine in a glass retort, until three-fourths of the fluid has passed over; place a piece or two of charcoal in the retort, to ensure equability of ebullition. Condense the vapor with cold water, close the joints of the apparatus by a paste, made of flour and water, with a little salt added.

155. Put into a glass retort $\frac{1}{4}$ of a pound of nitrate of potass, (saltpetre); to this add 2 ounces of sulphuric acid, being very careful not to spill the acid on the tube of the retort. Apply heat by means of a sand bath. As the heat required to drive over the acid is great, the vapor must not be condensed too rapidly, therefore it is advisable to have an intermediate vessel between the retort and the receiver, or condenser, as is seen below; where A is the intermediate vessel, and B the recipient for the acid when completely condensed. Make the joints tight with glazier's putty.

156. Distil dry nitrate of lead in a small glass retort, by the heat of a crucible furnace, condense the products in small dry flasks, cooled by a refrigeratory mixture, such as salt and pounded ice. Nitrous acid will pass over.

157. *To make aromatic vinegar.*—Put 2 ounces of acetate of potass into a retort with its weight of sulphuric acid; distil using a flask as a receiver, containing 1 ounce of water. Heat the retort by a lamp, and cool the flask by a basin of water. A solution of pure acetic acid will be obtained; if a minute quantity of camphor, a drop of the oil of lemons, and a drop of the oil of cloves be added, the result will be what is usually sold as *aromatic vinegar*.

158. Purify sulphurous acid by distillation thus:—Place it in a glass retort, and apply a gentle heat from a lamp. The acid will rise almost immediately. To condense it, tie

a bent tube to the retort, and another bent tube to the end of that; short tubes of Indian rubber being used to connect the one to the others. Immerse the tube attached to the retort in a glass, holding pounded ice and water; connect the second tube with the small flask or phial, which is to hold the acid, and immerse this in a mixture of 1 part salt, and 2 parts pounded ice. When the bottles are full, seal them up to prevent evaporation, which is very rapid. The following shows the arrangement of the apparatus:—

159. Rectify some ether in a glass retort, collect it in a flask, and use every possible means of condensing the vapor. The following cut will assist the understanding of several means of condensation. The ether passing from the retort meets first with water trickling from a funnel and falling upon folds of bibulous paper placed over the stem of the retort. A little farther down the neck water drops from a vessel at A on the neck, and from that to a vessel beneath; then passing into a tubulated receiver, it is partly cooled by the air striking the sides of the receiver. Finally, the liquid falls into the flask beneath—this flask being inserted into a vessel of water.

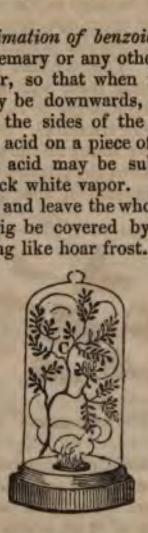
160. Make some strong spirits of wine out of common whiskey in the following manner: Put into a retort holding 2 quarts, 3 pints of whiskey, Irish or Scotch, add to it a dram of pearlash, the object of which is to mix with and retain the flavor of the whiskey, and which is occasioned by an empyreumatic oil, derived from the material from which the whiskey has been made. Distil by the heat of a charcoal fire, the retort being rested in a sand bath, until a quart has passed over into the receiver, which is to be cooled by a constant stream of cold water flowing upon it. The spirit obtained will be very strong and pure. In the cut A is the retort. B the receiver. C a basin or cistern, in which it is placed. D a cock, to carry off waste water. E cock, supplying the cold water used in condensation.

161. Always use distilled water for the purposes of solutions, &c. To make this in sufficient quantity a tin or copper still is generally employed. It may be of the following shape and make; also it may have a furnace of its own, or be made to fit the furnace formerly described. The cut shows a still; the head of which fits on to a collar or neck—the other end fitting to a worm, inclosed in a worm tub, which during the process of condensation is supplied with a continued stream of cold water, represented in the cut as flowing into the top of the tub; but in practice, on a large scale, it should flow through a hole in the bottom of the worm tub. The water when distilled flows from the lower end of the worm into any convenient vessel placed beneath.

162. *Fumigating pastiles.*—Put into an earthenware or metal pot a little gum benzoic in powder; drop upon the powder a piece of iron, a large coin, or other metal, previously made quite hot. This will sublimate the gum, which will fly off in dense white fumes, of a very fragrant odour. The agreeable character of the odour is much increased by the addition of a little ground cinnamon, Cascarilla bark, pounded frankincense, and camphor. This experiment teaches the method of making the incense used in Catholic religious ceremonies. If the above sub-

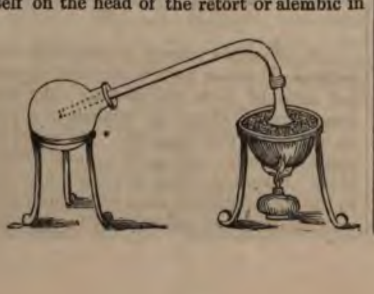
stances are mixed with thin gum water, and afterwards rolled up into pastiles, dried, and set fire to, they are useful in fumigating apartments.

163. *Sublimation of benzoic acid.*—Place a sprig of rosemary or any other garden herb in a glass jar, so that when it is inverted the stem may be downwards, and the sprig supported by the sides of the jar; now put some benzoic acid on a piece of hot iron—so hot that the acid may be sublimed in the form of a thick white vapor. Invert the jar over the iron, and leave the whole untouched, until the sprig be covered by the sublimed acid, appearing like hoar frost.



164. *Sublimation of sulphur.*—If pieces of sulphur or brimstone are placed in a vessel, such as that represented below, which is called an *alembic*, and heat be applied, when they are raised to the temperature of 170° they will be volatized, and the sulphur in powder will be found in the capital and receiver.

165. *Sublimation of indigo.*—In the same manner indigo may be sublimed; it settles itself on the head of the retort or alembic in the most beautiful copper-colored crytals, of the greatest brilliancy. It may be done with a flask and receiver; the former resting in a sand bath, or simply over a lamp.



166. *Another method.*—Bruise the indigo; put a small portion into an evaporating dish, and cover it over with a larger, but similar dish. Heat the lower dish by a spirit lamp, and keep the upper dish cool by a few folds of wet blotting paper. After some time the sublimed indigo will be found adhering to the under surface of the upper dish in a layer of crystals.

167. *Sublimation of mercury.*—This may be done in a common retort; but as the heat required is considerable, it is best to use a retort coated with clay. It must be placed in or over a furnace; the light of a lamp, except for a very small quantity in a tube or other minute apparatus, not being sufficient. The mercury will run down into the receiver as a liquid; the experiment is, therefore, one of distillation, and not of sublimation. The same quantity of mercury has been distilled as many as 411 times; yet no change takes place in its properties. Arsenic is readily distilled in the same manner.

168. *Sublimation of camphor.*—This sublimes very readily, and at a very gentle heat. The fumes are white, and settle on the surfaces of the apparatus in bright points. The heat of the sun will even make camphor slowly sublime, and the effects of the sublimation be very visible on the glass which contains the resin, as we often witness in the camphor bottles in chemists' windows. A curious and unaccountable fact occurs in these bottles; that is, we see the sublimed camphor adhering only to that side of the bottle which is exposed to the light.

169. *Sublimation of napthaline.*—Introduce some napthaline into a large flask or globe; place it on a warm part of the sand bath, and allow it to sublime slowly; close the mouth of the vessel with paper. When a sufficient quantity has sublimed, remove the vessel carefully on one side, till all is cold. Then shake out the crystals, and examine the beauty of their forms.

170. Sublime iodine in the same manner, both quickly and slowly; observe the beauty of the forms obtained in the latter case.

171. *Sublimation of calomel.*—Put a portion of calomel into a Florence flask, and sublime it into the upper part by placing the bottom in sand; make it quite hot, indeed nearly red hot. The sublimed mass will be very beautiful, but to be seen to advantage the flask must be broken.

172. *Formation of carbonate of ammonia.*—Place in a retort or flask an ounce of

powdered marble, and half as much powdered chloride of ammonia, mixing them previously well together. Sublime these mixed powders by the heat of a sand bath or an oil lamp. Incline the flask, and pass its neck through a cork into a cool receiver, or into the end of a wide tube, that may be cooled by the air, or if more convenient by water. The carbonate of ammonia will be obtained.

173. *Formation of the chloride of ammonia.*—This salt, one of the ingredients of the last experiment, is made by sublimation, by exposing animal and vegetable substances to heat in union with common salt. The ammonia is set free from the animal substances to combine with the gaseous hydrochloric acid. Both are thus condensed or solidified, and sublimed into chimneys, where they assume the form of white cakes.

CRYSTALLIZATION.

Most substances both simple and compound are found occasionally, if not always, in the state of crystals. Thus metals, salts, sulphur, numerous minerals, sugar, and many other materials are thus exhibited. This particular state is called crystallization, and the method of inducing it artificially is an operation which daily comes under the notice of the chemist, sometimes for economical purposes; but more frequently as the best mode of purifying his solutions, and as a convenient form in which to keep the various salts, &c., which it is necessary that he should employ. Most solutions, if concentrated by boiling, will deposit crystals as soon as a part of their water is evaporated, especially upon getting cold, and if before its crystallization the chemist be in doubt of the substance, it may be generally known afterwards by the form the salt presents, as every one assumes but one regular form, and is mostly quite distinct even in appearance from other bodies. They differ indeed in every respect in shape, color, size, and properties. Some circumstances are absolutely necessary to the formation of crystallized articles;—Firstly, that the liquid from which they are made should contain more of the salt than it can hold in solution;—and secondly, that it shall have access to the air, and in some instances a considerable length of time. These observations do not apply to the metals, sulphur, and other substances which crystallize when passing from a solid to a fluid condition. It is also to be borne in mind, that the slower the process the larger and more regular are the crystals obtained. The cautions to be observed in the crystallizing various bodies will be learned from the experiments.

Ex. 174. *Crystallization of alum.*—Make a solution of common alum, and set it aside; the liquid will gradually evaporate, and minute crystals be deposited at the bottom of the vessel. These by degrees increase in number, and grow larger. The shape of them will be similar to those in the annexed cut; the smaller of them are usually the most perfect, and are regular octohedra, or eight-sided figures. This is called their *primary* form, but among them will be found some which are without edges or angles, or rather have their angles truncated; these forms are called *secondary* forms of the crystal. The annexed cut shows the primary and secondary forms of the crystals of alum:—

175. *To make alum crystallized ornaments.*—Make a hot saturated solution of alum in water. Try if it be saturated by putting a drop of it on a slip of glass, and seeing if it crystallize as it cools; if so the solution is sufficiently strong. Then twist round a sprig of a plant, a cinder, or a wire ornament of any kind, some cotton, or still better some worsted. Suspend this in the solution, so that it shall not touch the vessel, and yet be wholly covered with the solution, Set the whole aside for twelve hours, when it will be found that the alum has crystallized over the whole surface of the suspended article, whatever it may be, in the most beautiful manner.

176. *To make colored crystallized ornaments.*—There are numerous colored crystals, but none of them are used to make ornamental works, except the sulphate of copper, on account of their expense. The above sulphate is cheap, and gives a most brilliant blue. For other colors it is only necessary to tint the solution of alum with some dyeing material, and then set it aside to crystallize

as in the last experiment. The addition of turmeric produces transparent *yellow* crystals; powdered litmus, or solution of litmus, produces *red* crystals; logwood makes them *purple;* and common writing ink *black.* The more troubled the solution looks, the finer are the crystals it affords, so that filtration is not necessary. These colored crystals are more easily destroyed than those of common alum; they may, however, be re-dissolved and re-crystallized at pleasure.

177. *Crystallize numerous salts together.*—Dissolve in seven different tumblers, containing water, ½ ounces of sulphate of iron, copper, zinc, soda, alumine, magnesia, and potass. Pour them all, when completely dissolved, into a large evaporating dish, and stir the whole with a glass rod. Place the dish in a cool place, where it cannot be affected by dust, and where it may not be agitated. When evaporation has taken place, the whole will begin to shoot out into crystals. These will be interspersed in small groups and single crystals amongst each other, giving a very curious appearance to the general mass. Let it be remembered, that in this experiment the sulphate of copper, (blue stone,) never fails to communicate its own blue tinge to the alum, and other white crystals; nor are the crystals so fine and regular in shape as when crystallized separately.

178. *To obtain large artificial crystals.*—To obtain large artificial crystals of a regular shape requires considerable address, and much patient attention, but the result fully recompenses the trouble. The method of M. Leblanc is as follows:—The salt to be crystallized is to be dissolved in water, and evaporated to such a consistency that it shall crystallize on cooling. Set it by, and when quite cold pour the liquid part off the mass of crystals at the bottom, and put it into a flat-bottomed vessel. Solitary crystals form at some distance from each other, and these may be observed gradually increasing. Pick out the most regular of these, put them into a flat-bottomed vessel, at some distance from each other, and pour over them a quantity of liquid obtained in the same way, by evaporating a solution of the salt, till it crystallizes on cooling. Alter the position of every crystal, once at least every day, with a glass rod, that all the faces may be alternately exposed to the action of the liquid; for the face on which the crystal rests never receives any increase. By this process the crystals gradually increase in size. When they have acquired such a magnitude that their forms can easily be distinguished, the most regular are to be chosen, or those which have the exact shape which we wish to obtain; and each of them is to be put separately into a vessel filled with a portion of the same liquid, and turned in the same manner several times a day. By this treatment they may be obtained of almost any size we think proper. Whenever it is observed that the angles and edges of the crystal become blunted, the liquid must immediately be poured off, and a portion of new liquid put in its place; otherwise the crystal is infallibly destroyed.

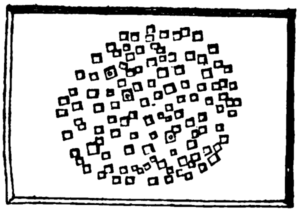
179. *To convert several small crystals into one large one.*—This is an experiment of Dr. Wollaston. If a small quantity of sulphate of nickel in solution, with a slight excess of acid, be evaporated in a watch glass, it will probably, on cooling, yield a crop of numerous small crystals; but if set aside for a few weeks, in a place subject to the changes of atmospheric temperature, its appearance will gradually alter; the small crystals disappearing, the larger increasing until ultimately only one or two are left. Dr. Faraday explains the above experiment thus:—"This effect depends on the greater extent of surface exposed by the small crystals, as compared to their mass, than by the larger crystals, so that when any increase of solvent power in the surrounding fluid is occasioned by a slight increase of heat in the atmosphere, the small crystals dissolve to a greater extent than the others; but upon the decrease of temperature the deposition is equal upon all. The same effect may often be observed in solutions confined in glass bottles, as in oxalic acid, nitrate of mercury, acetate of lead, &c. The small crystals, which were formed when the solutions were first made, being gradually converted into others of considerable magnitude."

180. *To crystallize glass windows, and therefore to render them semi-opaque.*—Make a hot saturated solution of Epsom salts, or still better of sal ammoniac. Wet the glass window with this solution, laid on equally with a paint brush. The moisture will almost instantly be evaporated, and the salt be deposited in a very beautiful radiated form. This deposition will admit the light, yet cannot be seen through; and for rendering windows semi-opaque is infinitely to be preferred to paint, paste, or other materials employed for this purpose.

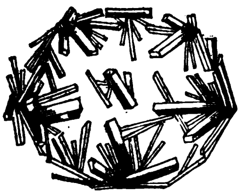
181. *To form crystallized microscopic objects.*—Wash over the surface of a slip of glass, a hot saturated solution of the required salt, as in the last experiment. It will crystallize in its normal and natural form, and present a most beautiful figure of crystalli-

zation, when examined by a pocket lens or a microscope. Sal ammoniac will give an aggregation of crystals of the foregoing character.

182. Another method is to put a single drop of the solution on a slip of glass, and let it slowly or quicky evaporate; thus several specimens may be preserved on the same slip; if common salt be used, the crystals will assume a cubical form, as under.



183. Instead of common salt, use Epsom salts, the crystals will be very beautiful, representing four-sided prisms, with flat ends.



184. If either nitre or Glauber's salt be used in lieu of the above, the result will be six-sided prisms, with pointed ends. And to vary the experiment, the drop of the solution may be put upon a hot piece of glass, and immediately placed under examination; when as the evaporation proceeds, the crystallization may be witnessed.

A small quantity of blood or of skim milk added to the saline solution will materially alter the form of the crystals. Any other salts may thus be examined; among the most interesting are boracic acid, nitro-muriate of gold, corrosive sublimate, acetate of morphia, and of copper, Rochelle salt, prussiate of potass, sulphate of quinine, borax, sulphate of copper, deutioduret of mercury, chloride of copper, nitrate of silver, chromate of potass, nitrate of nickel, phosphates of lead and of copper, sulphate of cobalt, and chlorate of potass.

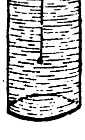
185. *Crystallization attended by decomposition.*—Dissolve in warm water, ½ ounces of chloride of potass and nitrate of ammonia, and pour both solutions into the same vessel. Upon evaporating and cooling two kinds of crystal will be formed; but neither will be like those dissolved, for the hydrochloric acid of the chloride of potass will unite with the ammonia, forming chloride of ammonia; leaving the potass to be taken up by the nitric acid, to form nitrate of potass.

186. *Crystallization of two salts without decomposition.* — Pour a solution of ½ an ounce of sulphate of iron, and the same quantity of chloride of soda, (common salt,) together into an evaporating dish; on due evaporation, each salt will form its own crystals, without being affected by the other, though both the acids and the bases of them are dissimilar.

187. *Crystallization assisted by exposure to the air.*—Make a hot solution of Glauber's salts, fill a phial with one portion of it, and cork it up while hot; fill a second phial with another portion, and leave it open at top. Place both these phials so that they shall not be disturbed for some hours, the salt in the open phial will be found crystallized, that in the closed phial still liquid.

188. *Agitation promotes crystallization.* —Uncork the phial containing the uncrystallized solution of the last experiment, but without disturbing it. If the cork has not touched the liquid, and the phial is kept without agitation, it is probable that it may even when uncorked not crystallize. If so, shaking it will suddenly convert the whole fluid into a mass of crystals, so that the phial may even be inverted without any liquid running out, although exposed to the air during all the period of cooling; if in a very quiet atmosphere, and a narrow-necked vessel, it is very often found that solutions do not crystallize; a crystal of the same salt as that in the solution dropped into it will occasion the whole to crystallize instantly.

189. Make a solution of Glauber's salts, (sulphate of magnesia,) as before; drop into it while hot a leaden shot, or a fragment of cinder, tying it to a hair or filament of silk, the other end of which holds a piece of cork. Suspend this in the solution while hot, cork the vessel, and set it aside to crystallize. Instead of its remaining fluid, as before, the shot will form a nucleus, around which the whole will crystallize readily.



190. Nearly fill a phial with the same hot saturated solution, and pour on to the top of the liquid a little olive oil. This will cool without crystallizing. When smartly agitated it becomes solid, with the usual phenomenon of the crystals shooting from the top downwards. If, when the salt has crystallized in any of these experiments, you plunge the phial containing it in hot water, it will be again dissolved. You may then cork the phial as before, and the same solution will serve for a repetition of the experiment.

191. Dissolve 4 parts by weight of crystallized sulphate of soda, (Epsom salts,) and 3 parts of saltpetre, in 15 parts of warm water. Divide the solution into two portions; in one of these portions place a crystal of saltpetre, and in the other a crystal of sulphate of soda. Cover up the two solutions that they may crystallize without evaporation. Although the two salts are mixed together in the solution, yet only one salt will crystallize in each portion; that containing the crystal of saltpetre will deposit saltpetre, and that containing the crystal of sulphate of soda will yield only the same. This phenomenon is explained by assuming that the attraction between the particles of saltpetre and saltpetre is greater than that between saltpetre and water, or between saltpetre and sulphate of soda.

192. *Arborescent crystallization.*—Solutions of numerous salts, if left exposed to slow evaporation for a length of time, will not only deposit crystals at the bottom of the liquid, but a curious formation of a fine, irregular mass of efflorescing crystals will spread over the sides of the vessel containing the solution, especially if it be earthenware. This is the case with sulphate of iron, sulphate of copper, and still better the acetate of lime, with which the experiment may be tried.

193. *Crystallization of sugar.*—Make a strong solution of loaf sugar, pour the syrup thus made into a vessel of any kind, which place in a slow oven; the evaporation being rapid, the sugar will be deposited in very small crystals, or, in fact, the whole will become loaf sugar again. Place some of the same solution in a pan, stretch one or more strings across the vessel, and set it aside, so that the evaporation may be very slow; instead of the sugar presenting a fine granular surface as before, it will appear in large well-formed crystals clinging to the strings. In this state we know it as sugar candy. Barley sugar is not a crystallized but a fused mass, obtained by melting sugar by heat, and without water, it then becomes a shapeless transparent mass, which is made by hand into various forms.

194. *Crystallization of verdigris.*—Verdigris is the acetate of copper, crystallized upon wires suspended from the top of a vessel containing a saturated hot solution.

195. *Crystallization of bismuth.*—One of the most beautiful instances of crystallization is that of the metal bismuth. This cannot be done to perfection, unless 2 or 3 pounds of the metal are used at once. Put these into a crucible or deep iron ladle, submit this to heat until the whole is melted: then set it aside, and watch the time when the metal congeals on the surface; when this is the case, pierce the surface with an iron rod, and pour out the fluid metal beneath, let the crust remain until perfectly cold, otherwise it will be brittle; turn it out of the crucible, it will present the most elegant arrangement of crystals of the annexed character.

196. The same may be done with lead, arsenic, zinc, antimony, tin, and other metals; also very readily with sulphur. The crystals of the metals are mostly cubes or octohedra. Those of sulphur are needle-shaped.

OTHER CHEMICAL OPERATIONS.

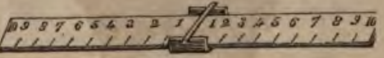
The effects of heat and combustion in promoting chemical changes, and also these latter in occasioning numerous phenomena, whereby the latent heat of bodies is sensibly affected, come under our notice in almost every important operation of chemistry, as we have already had occasion to remark under the introductory experiments; as well as in those devoted to mixture, solution, distillation, sublimation, &c. So universal, indeed, is this power, that for the future examples will abound of the mechanical and chemical effects of caloric, or the matter of heat. We, therefore, defer the consideration of this subject to a future time, when the nature of chemical materials, or elements, shall have been explained. So also the manipulation of gases will best be understood when the gases are treated of, especially as almost each gas requires a different management. We will close the chapter, therefore, with a plain description of a few cheap and necessary articles of apparatus, which the student will require in carrying on any extensive series of operations.

Lamps and furnaces.—A spirit lamp is of the first necessity; it may be made of glass or tin. One of the common tin chamber lamps, which may be bought at any tinman's for 8*d.*, will answer every purpose; or a short, thick glass phial, with a tin lamp top, made to fit on the mouth of the phial, might equally be made available. The wick is always solid, and may be made of fourteen or sixteen strands of common lamp cotton. The meaning of the word solid is, that there should be no orifice for the admission of air through the middle of the wick. The material to be burnt is spirits of wine; as, however, this is expensive, *pyroligneous spirit*, sold at about 1*s.* 6*d.* per pint, may be used instead. The advantages of a spirit lamp are, that it produces a great heat, without any smoke, is easily managed, and is not accompanied by a disagreeable smell, nor is the accidental spilling of the spirit of much consequence. Spirit lamps are used mostly for short operations, rather than to supply a long-continued heat.

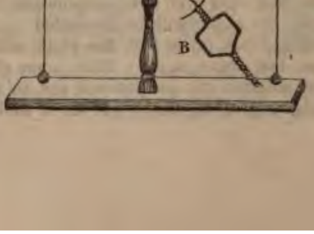
Oil lamp.—A stronger degree of heat is furnished by an Argand lamp, or one which admits a current of air through the flame; such as those used as table lamps, suspended lamps, &c. Droppings of sweet oil is the cheapest fuel. The power of oil lamps may be materially increased by having a copper funnel, instead of the usual lamp glass. Also for chemical purposes the Argand lamp is usually made short, and with a wire frame above it, to serve as a support for a retort.

Furnaces.—A very useful furnace has been already described, (see page 23.) An ordinary grate may be used for most purposes of the chemist; indeed there are few experiments which require any other, except those of smelting metals, and fusing refractable substances. Should the experimentalist, however, desire one expressly for chemical use, an extremely convenient one may be had at Knight's, Foster Lane, for from £3 to £5; or he may make one for himself of iron plate, observing that every good furnace should have a register, or door, to the ash-hole, to diminish the draught of air; it should also have a hole near the bottom of the fire, closed upon ordinary occasions, but which will admit the nozzle of a pair of bellows when a more intense heat be required. On two sides should be holes, to admit a gun barrel to pass through the fire; it should have a door to admit crucibles, &c. The top must have an iron case to fit into over the fire, for a sand or water bath; and the whole be covered with a dome, to reverberate the heat when the sand bath is not in use. The use of the bellows constitutes the above a blast furnace, and the dome forms it into a reverberatory furnace. Messrs. Knight also sell a table black-lead furnace for about 14*s.*; it is not either more effective or convenient than Mr. Faraday's before described.

Balances and measuring apparatus.—Measuring and weighing are decidedly mechanical operations, yet chemists are obliged constantly to have recourse to them. A pair of common scales will answer ordinary purposes, or a balance made of a straight slip of dry wood, and marked as in the following cut will be found convenient; it is the invention of Dr. Black. He says, "The apparatus I use for weighing small globules of metal, or the like, is as follows:—A thin piece of fir wood, not thicker than a shilling, and a foot long and half an inch broad, is divided into 20 parts; that is, 10 parts on each side of the middle. These are the principal divisions, and each of them is subdivided into halves and quarters. Across the axis is fixed one of the smallest needles I could procure, to serve as an axis, and it is fitted to its place by sealing wax. The fulcrum is a piece of brass plate, the middle of which lies flat upon the table; the two ends are bent at right angles so as to stand upright. These two ends are ground at the same time on a flat hone. They rise above the surface of the table only $\frac{1}{8}$ of an inch, so that the beam is very limited in its play. This balance will weigh the minutest quantity, even the 1200ths of a grain. A grain weight is placed on one division of the balance, and the object to be weighed on another; the position of the two will indicate the weight of the latter."



An extremely convenient balance may be made as follows:—Procure a slip of wood, as in the last instance, and suspend it in the same manner, but upon a higher stand.



Make two light scales of ivory, and suspend each scale to a wire, as in the figure. Put a small bullet, or other weight, at the lower end of each wire. Suspend each scale upon the beam, and according to its position so will be the weight it indicates. A previously-ascertained weight being put into one scale, and the material to be weighed in the other, the scales may be suspended upon a straight square wire, and this being pierced may be supported by a needle passing through the sides of the beam.

For *weights* common leaden shots may be used. They may be had of a grain or half grain in weight, and of any larger size. Still more accurate weights may be made of brass wire; take the spring wire which is made by winding one wire evenly upon another, and such as is used for the covered harp, or violin strings, or for elastic braces, bell springs, &c. According to the minuteness of the weights desired, hold an inch or two of this in a vice, and laying a sharp knife along it, give the knife a blow, when it will cut the coil of wire into a great number of rings, which form equal, delicate, and convenient weights; or weights of a certain size may be made thus:—Weigh a certain length of wire, filing it till it weighs exactly a grain; twice this length will, of course, be two grains, and so on for others. The weights requisite for convenience are ¼, ½, 1, 2, 4, 6, and 12 grains; 1, 2, and 6 pennyweights; 1, 2, 4, 6 ounces; 1, 2, &c. pounds.

Hydrostatic balance.—This instrument is merely an ordinary pair of scales, mounted upon a high stand. It is represented and used as follows:—

Ex. 197.—*To find the specific gravity of a solid lump, heavier than, and insoluble in water.*—First weigh it by the ordinary method, and note its weight. Then suspend it by a filament of silk, or a horse-hair, from one of the scales, and suffer it to hang in a vessel of water. Note what it weighs under these altered circumstances; divide the first weight by the difference of the two weights—the result is the specific gravity.

198. *To find the specific gravity of a solid lump, lighter than, and insoluble in water.*—Annex to the lighter body another which is much heavier than the fluid, so that the compound mass may sink in the fluid. Weigh the heavier body, and the compound mass separately, both in water and out of it; then find how much each loses in water, by subtracting its weight in water from its weight in air; and subtract the less of these remainders from the greater. Then, as this last remainder is to the weight of the light body in air, so is the specific gravity of the fluid to the specific gravity of that body.

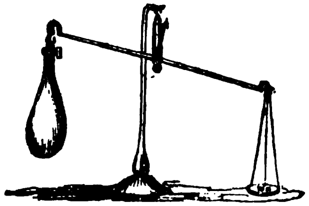
199. *To find the specific gravity of a solid lump, soluble in water.*—This differs in no way in the manner of its performance from *Ex.* 197, but the rule to find the gravity is that of the last experiment; the difference of weight in air, and in the liquid, whatever it may be, whether alcohol, oil, or spirits of turpentine, being the first term: that is, as the loss of weight is to the whole weight in air, so is the gravity of the fluid to that of the solid.

200. *To find the specific gravity of a liquid.*—To one of the scales attach as before, a ball of lead or glass, and balance it in the air. Immerse the globe in the fluid to be weighed, and observe what weight balances it then, and consequently what weight is lost, which is in proportion to the specific gravity as before. And thus the proportion of the specific gravity of one fluid to another is determined by immersing the globe successively in all the fluids, and observing the weights lost in each, which will be the proportions of the specific gravities of the fluids sought.

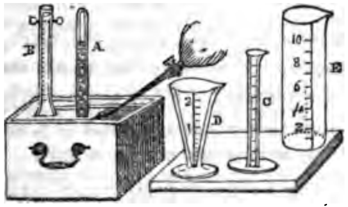
201. *To find the specific gravity of a powder.*—Fill a phial with water, and mark the weight of the whole accurately in grains. Now weigh 100 grains of the substance to be examined, and drop it gradually into the water in the phial. The difference in weight of the bottle with its contents now, and when it was only filled with water, will determine the specific gravity of the substance under examination. For example, if the bottle weigh 40 grains more than it did when it was filled with water only, it shows that 100 grains of the mineral displace only 50 of water, and consequently that it is exactly twice the specific gravity of water. This would be exactly the case with alumine and very nearly so with sulphur, opal, and rotten stone.

202. *To find the specific gravity of the air or of a gas.*—Procure a copper or glass flask, capable of holding an exact quantity, as 100 cubic inches, a pint or any other convenient amount. Let there be a cap and stop-cock to the flask, which will fit the end of an exhausting syringe, or the table of an

air-pump. First, weigh the flask of air, as represented below, then exhaust it of air by the pump, and weigh it again in the same manner; the additional weights now required, will give the weight of the air or gas driven out. Then as the contents of the flask in cubic inches is to the additional weights, so is 1 foot or 1728 cubic inches to the specific gravity.

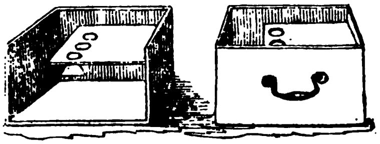


203. ***Measuring glasses*** scarcely need description; those used for measuring liquids are open at the top, and have their sides marked for the particular quantities they are to hold. It may be 10, 20, 30, 40, 50, and 60 for the smallest of them (C,) called a *minim* glass; 60 drops making a minim—the marks and numbers indicate the number of drops it will hold up to a certain mark. The next size is the ounce-glass, marked for ¼, ½, ¾, 1, and up to 2 ounces, (D.) A third glass wider at the lower end is used for larger quantities, 2, 4, 6, 8 ounces and upwards, (E.) The measuring glass for gases is called a eudiometer, it is graduated in cubic inches. It is used thus:—Fill it with water, or, if the gas be absorbable in water, with mercury, place it mouth downwards over the hole, on the shelf of a pneumatic trough, and suffer gas to issue from a pipe, retort, or bladder into the lower end of it; the gas will rise through the water and occupy the upper end of the tube. The following will show the method of performing the operation, and also the form of several measuring glasses and eudiometers standing about



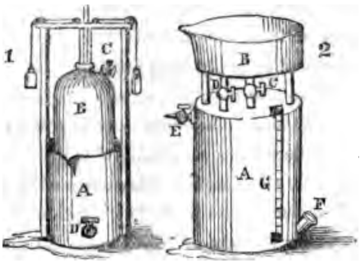
Besides the above common apparatus, little else will be required for the experimental chemist, except such articles as are adapted to the holding and experimenting with the gases; these are chiefly gas jars, gas-holders, or gasometers, and a pneumatic trough.

The pneumatic trough is a tin box, 10 inches wide by 14 long. It is without a top, but has a shelf extending over a part of its surface, and rested on a small shallow ledge fastened to the sides of the box, so that the top of the shelf may be from 1 to 2 inches beneath the upper edge of the box; through the shelf are 2 or 3 holes, to which are attached on the under surface as many small funnels of tin; one of these is represented in the sectional cut. Supposing gas is issuing out of the beak of a retort, and that beak were placed beneath the funnel, the shelf being covered with water; it is evident that the gas would pass through the funnelled hole and ascend into the air if the hole were uncovered, or else into a gas jar or other vessel placed over the hole. Also in passing through the water, the gas becomes purified and cooled.—These are the objects of a pneumatic trough.



Instead of tin, a common wooden box may be used. It is only necessary that it should be water-tight, and a common box may be easily made so, by running a little pitch or a mixture of rosin and wax along the various joints—even a washing basin with a small three-legged stool standing in it will answer every purpose. A small foot tub makes an excellent trough, and a small garden pot, with a hole made in the side to receive the beak of the retort, will make an equally excellent shelf to it, so easy is it to find chemical apparatus.

Gasometer and gas-holder. There are two totally different instruments used ordinarily for the holding of gases,—they are both represented in the following cut.—No. 1, is the ordinary gasometer, and No. 2 is Pepys' gas-holder.



A and B in figure 1 are two tin vessels, one fitting loosely into the other. A is a fixture. B moves up and down, its weight being counter-balanced by two weights, which are attached to strings that pass over pulleys, &c., which are partly or wholly inserted in a frame-work, projecting considerably above the top of A. B may therefore be lifted entirely out of A, or it may be immersed entirely into A. C is a cock to draw the gas out, and D is a cock to let the gas in; this cock is connected to a pipe which leads quite up to the middle of A, the top of it touching the top of B, when B is depressed. To use the gasometer, fill A with water till the water runs out of the cock D, which must of course be open; shut C; force B down into the water as much as possible; fasten the mouth of the retort when gas is being made to D, and lute the joint with common lute. (See *Ex.*153) The gas having no other egress will rise into B, and as it fills B, it will buoy it up to the position shown in the cut. When the operation is complete, close the cock D. When the gas is wanted for use, it may be drawn out of either of the cocks by a flexible tube, or a bladder being attached to that which is most convenient; pressing the vessel B down into the water by the hand, or if a constant stream of gas be required, as for the purpose of illumination, a weight may be laid upon it, proportionate to the size of the stream required.

Pepys' gas-holder consists of two tin vessels, A and B, placed over each other. A is closed on every side. B is open at the top. These communicate by two cocks C and D. D merely connects the two, but C has a pipe which extends to very near the bottom of A. C is used to pour water into the under vessel. D and E are used to draw off the gas. F is where the gas enters into the vessel A; and G is a glass tube opening into A at each end. The manner of using this instrument is described in *Ex.* 205. A common bladder is also a very useful gas-holder. Gas also may be caught in phials, and these being corked, or having their stoppers properly inserted immediately they are full of gas, form very useful gas-holders for small quantities of gas. It is to be remarked that many gases, chlorine for example, are absorbable by water; for such as these, troughs, phials, &c., filled with mercury, must be employed, as will be described in treating of the various elements hereafter. A bladder rendered pliable by soaking, and then rubbed dry, may be used for a time, until the gas, that is if it be of a corrosive nature, destroys the texture of the bladder. Indian rubber bladders, or waterproof cloth bags, are very serviceable for this purpose, and form indeed the most convenient gas-holders.

Gas jars and bottles are of various forms, according to the purpose intended to be accomplished. The most usual are seen in the experiments. Those which are open at the top, may be closed with well-fitting corks—or it is as well for some experiments to have the mouth made wide, and ground flat at the top, that it may be covered with a piece of plate-glass.

CHAP. II.

ON THE NON-METALLIC CHEMICAL ELEMENTS.

THE chemical elements are such bodies as have never been decomposed, and which are therefore supposed to be simple or primitive substances. On account of the great tendency some of them have to unite with the rest, they are never found in a free and uncombined state, and to be obtained pure must be extracted from various bodies of which they form a part; so also their properties are to be told chiefly from their action upon each other, or upon organic bodies, into the composition of which the gaseous elements and carbon form at all times the most considerable portion.

The elements are divided into metallic and non-metallic. Those of the former class, called metals, are with the exception of mercury all solid. The non-metallic elements may, for the sake of convenience, be divided into the gaseous, liquid, and solid, which terms have reference only to the state of bodies when subjected to the usual atmospheric pressure and temperature; for be it observed, that although some gases are permanently elastic under all circumstances in which they have been experimented upon, yet the application of inordinate pressure or extreme cold, to other gases, changes them into liquids, and even these into a solid state. Ordinary liquids are for the most part affected in the same way, and even more readily; while a great increase of caloric or heat decomposes or rarefies the solids, so that they are either liquefied or resolved into gaseous elements.

A *gas* is an elastic body, not changed into a liquid by the ordinary influence of the atmosphere, as the air.

A *vapour* is an elastic body, changeable into a liquid by cold, as steam.

A *liquid* is a non-elastic body, the particles of which move freely among each other, as water.

A *solid* is a body, the particles of which are fixed to each other, and are therefore incapable of motion among themselves, as gold, &c.

NON-METALLIC ELEMENTS.

Gaseous	Which have not been liquefied ..	Oxygen, hydrogen, and nitrogen.
	Capable of liquefaction........	Chlorine.
Liquid		Bromine, and perhaps fluorine.
Solid		Iodine, carbon, sulphur, phosphorus, boron, selenium.

OXYGEN; ITS PROPERTIES AND PREPARATION.

OXYGEN was discovered by Dr. Priestley in 1744. It is a colorless gas, has neither taste nor smell, is not affected by light or heat, is rather heavier than atmospheric air, its specific gravity being 1·111—is very sparingly absorbed by water, possesses neither alkaline nor acid properties, and combines with all the other simple bodies, producing with some of them acids—with others oxydes. It is one of the constituent principles of air and of water—is the most perfect of all supporters of combustion, and is absolutely necessary for animal existence; the atmosphere being adapted to support combustion and animal respiration, only in proportion to the quantity of oxygen it contains. By the absorption of this gas, the venous blood when passing through the lungs becomes purified from carbon, and restored to the bright red color which arterial blood presents. Its influence upon colors is often very great, and is taken advantage of by dyers. Oxygen is given off naturally by growing vegetables, and may easily be procured artificially by abstracting it from the metallic oxydes, or the salts which contain it, and also by the decomposition of water by galvanism.

Ex. 204. *To procure oxygen from vegetables.*—Put into a wide-mouthed bottle a quantity of fresh-gathered leaves, such as vine or cabbage leaves; fill the bottle with water, and turn the mouth downwards into a saucer, full of water. Place this in a hot sunshine, and after some hours the upper part of the glass bottle will be filled with gas, which by a proper test will be found to be oxygen.

205. *From black oxyde of manganese only.*—Put into a gun barrel, which has previously had its touch-hole stopped up, 4 ounces of the binoxyde, commonly called the black oxyde of manganese, in powder. Place it in the fire, and when approaching a red heat oxygen gas will begin to pass out at the open end, as may be known by the increased flame of a candle held to it. When this is the case, fasten a collapsed bladder to the open end of the barrel, so as to be air-tight, when the gas will pass into it, and may be preserved for use. It is not perfectly pure, but sufficiently so for ordinary experiments. Instead of the bladder, a pewter tube may convey the liberated gas either to a gas-holder, or to glass receivers, placed upon the shelf of the pneumatic trough for its reception. When the gas is wanted in considerable quantity, an iron bottle should be used.

The binoxyde of manganese yields an eleventh of its own weight of gas, and as 3 cubic inches of oxygen weigh 1 grain very nearly, we easily find the quantity of gas to be made from a given quantity of materials. Thus from 4 ounces, avoirdupois weight, of the binoxyde, 4 ounces or 1750 grains divided by 11, and that quotient multiplied by 3 for the number of inches of gas. The result will be about a pint more than 2 gallons; though owing to the impurities of the binoxyde, and the difficulty of driving over the last portions, seldom more than 5 gallons can be obtained from a pound. Oxygen will keep any length of time in glass bottles, and for some weeks in dry gasometers.

The above apparatus shows the usual method of making oxygen if wanted in a considerable quantity. It shows an iron bottle immersed in a common fire, connected with a gun-barrel, and that connected with a small pipe which leads to the gas holder. The manner in which the whole is to be set to work, is as follows :—Put into the iron bottle, the quantity of the binoxyde—fasten the connecting tubes to it, and rub round the joints a little wet clay. Then fasten the screw on to the orifice at the bottom of the gas holder, where the pipe is afterwards to enter, then open all the cocks at the top, and pour in water until it issues out of the side-cock. When this is the case, close all the upper cocks, and open the lower orifice, the water, there being no vent above, will not flow out. Then elevate the gas-holder over a tub, by putting it on a stool or other convenient stand, adjust the bottle in the fire, and take care that the end of its conveying pipe will pass into the lower orifice of the gas-holder, but do not insert it yet. Increase the heat of the fire until the bottle is red hot, and every now and then hold a lighted taper or other burning body to the end of the pipe. It will be at first, and perhaps for a considerable time afterwards extinguished; this shows that no oxygen is liberated, but only carbonic acid—when the flame of the taper is increased in brilliancy, by being applied to the orifice of the pipe, it shows that oxygen is passing, and the pipe must be immediately inserted into the gas-holder, which will gradually fill with gas, the water running out in like quantity into the tub. The progress of the manufacture will be seen by the glass gauge pipe of the gas-holder.

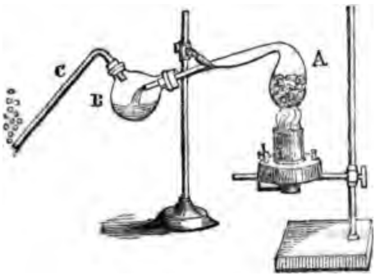
When full, or when no more gas rises, withdraw the pipe of the gas bottle, and fasten up the lower orifice; the gas-holder may be removed for use. It is to be obtained as follows :—First, fill the upper chamber with water, and *always keep it full*, then open the middle large cock, and let the water run down if it will, supplying more from time to time as required. If the gas is wanted to be thrown upon ignited charcoal, a blow-pipe is to be screwed on to the side cock, and the cock being opened, the gas will escape from the orifice of the blow-pipe. If it be wanted in a jar, fill the jar with water in a pail or tub, turn it with the closed end uppermost, without lifting the whole quite out of the water, put a plate or saucer beneath and lift the whole up; the jar will remain full of water, and thus may be transferred to the top of the gas-holder, being careful not to remove the plate till the lower end of the jar is again immersed in water. Slide the jar thus filled over the small cock of the gas-holder, turn the cock on, and gas will flow up into the jar and displace the water. When full, it may be removed by means of a saucer being put under it as before. These observations will apply to most of the gases. The carbonic acid herein spoken of is of less consequence, (using a gas-holder,) than it would be if a bladder were fastened to the end of the pipe, because the water of the gas-holder will absorb most, if not all of it; but if a common bladder only were attached, there being no water in contact with the gas, it would mix with the oxygen afterwards emitted.

206. *From nitrate of potass. (Saltpetre).*—Dr. Reid writes thus, in his "Elements of Chemistry." The nitrate of potassa is another substance that is frequently employed for the preparation of oxygen, when it is not wanted particularly pure. It may be exposed to a red heat in any of the kinds of apparatus previously described, with the exception of glass retorts. The first portion of oxygen which escapes is comparatively pure, but afterwards it is loaded with nitrogen, and various gaseous compounds of nitrogen and oxygen. When nitre is used for the preparation of oxygen, the vessel in which it is contained should never be filled more than one-third full, for when oxygen escapes from the melted nitre, the whole is thrown into a state of ebullition, and were a larger quantity used, part would probably be thrown into the tube which conveys away the gas, and being immediately solidified there, would not only prevent the further escape of gas; but might give rise to serious accidents, from the accumulation of gas pent up in the interior of the vessel, and exerting a strong expansive force.

207. *From binoxyde of manganese and sulphuric acid.*—Place in a glass retort 4 ounces of the binoxyde of manganese, and add to it strong sulphuric acid, sufficient to make it of the consistence of cream. Apply the heat of an Argand lamp, and the gas will pass over when the mixture boils. This is only useful when an iron retort is not at hand, being a more expensive and troublesome mode than the last, especially as the glass retort is apt to be cracked by the caking

together of the materials. Take care that the materials are well mixed together, previously to applying the heat.

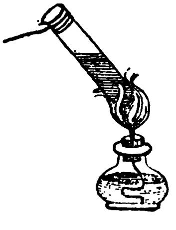
208. *From binoxyde of mercury. (Red precipitate)*—In the same manner as that described in *Ex.* 206, oxygen may be made of the binoxyde of mercury, every 219 parts consisting of 203 of mercury, and 16 of oxygen. In this case, the whole of the oxygen is expelled on exposing the binoxyde to heat. As the mercury is at the same time volatilized, it will fall into the receiver along with the gas, therefore, no part of the apparatus should be made of any metal with which it may combine, such as lead, tin, copper, brass, &c. A coated *green* glass retort may be used, or still more effectually, an earthenware or an iron retort. It was from this material that Priestley first obtained the gas. The best apparatus for the purpose is as follows:—where A represents the retort.



B a receiver, intermediate between the retort and gas-holder, intended to catch the distilled mercury. C a pipe, which conveys the gas to the receiver.

209. *From chlorate of potass.*—Put into a glass retort a quarter of an ounce of the chlorate of potass. Place a lamp under it, and when it arrives at nearly a red heat it is wholly resolved into very pure oxygen gas, (which may be collected in the usual way), and a white powder, called chloride of potassium, which is left in the retort. The above quantity of salt yields rather more than half a pint of gas, or about one entire inch of gas for each grain of the salt.

210. *Ditto, in a small quantity.*—If a very small quantity only be wanted it may be made in a test tube, supported by a wire. If when the gas is rising, or in other words, when the chlorate is boiling, a slip of burning wood be held above the chlorate and in the gas, the flame of the wood will be much increased in brilliancy, and if it be allowed to fall into the melted chlorate of potass, a sudden deflagration takes place within the tube, in the manner shown in the tube at the side of the cut.



211. *Combustion of a taper.*—If a lighted taper be immersed in a jar of oxygen gas it will burn with much more than ordinary vividness and rapidity; and if the taper be extinguished, but so as to leave the wick still kindled, and then immersed, it will instantly become inflamed. This may be performed several times with the same jar of oxygen.

Note.—A modification of this experiment forms the celebrated *Bude Light*, which is nothing more than a stream of oxygen passing through a burning lamp, the brilliancy of which is thereby greatly increased.

212. *Brilliant red fire.*—Dissolve in spirits of wine as much as it will take up of the nitrate of strontian—light the spirit, which will burn with a faint red light. Immerse it while burning in a jar of oxygen gas, and the brilliancy of the flame will be very greatly increased, and appear of the most vivid red. A variation of this experiment may be made by putting a little of what is called red theatrical fire into the deflagrating spoon, (in the manner shown in *Ex.* 219,) and introduced into a jar of oxygen; the light will be most brilliant and beautiful in color.

213. If a few crystals of nitrate of strontian be placed upon a piece of charcoal, (as shown in *Ex.* 225,) they will burn with intense vividness when a jet of oxygen is projected upon them. The same will be the case with the substances in the following illustrations.

214. *Dark red flame.*—Dissolve chloride of lime in spirits of wine, inflame it in oxygen, and it will burst into a larger and stronger flame of a dull red light.

215. *Green light.*—Instead of chloride of lime use a few crystals of boracic acid, stir it well to dissolve the acid, and after inflammation and immersion in the oxygen a beautiful green flame will be produced. The same will take place if the nitrate of copper be used.

216. *Yellow flame.*—Dissolve carbonate of barytes in spirit of wine, inflame it under the same circumstances, and the flame will be yellow. The same will be the case if the chlorate of soda or common salt be used.

217. *A reddish yellow flame* is produced by burning in the same way chloride of magnesia.

218. *White light.*—Many substances burnt in oxygen will produce a white light, as caoutchouc or Indian rubber, most of the resins, &c. That however which produces the clearest and most brilliant white, next to phosphorus, is a small piece of camphor suspended from a wire in a jar of the gas.

219. *Combustion of phosphorus.*—Fill a jar, which has an open top, with oxygen, and introduce into it a deflagrating spoon, containing a small piece of phosphorus lighted. It will instantly burst into the most intense and vivid flame, so that the eye can scarcely bear the intensity. A dense white fume will, at the same time, fill the jar—this is phosphorous acid; and is an example of the union of oxygen with another body to form an *acid.*

The jar in all these experiments should have a wide mouth, and the stem of the deflagrating spoon pass through a good cork, which fits the orifice of the jar; and being open below it should always stand in an inch or more of water, to prevent accident; or if a wide-necked bottle be used, a little water should be left in it. When phosphorus in combustion is introduced into oxygen, nitrous gas, and nitrous oxyde, no attempt should be made at the close of the experiment to withdraw the deflagrating spoon with phosphorus still burning; the light being too dazzling to do so without incurring the risk of contact with the lip of the jar. Should a fragment of burning phosphorus fall on the surface of the glass, it will certainly occasion its fracture, unless immediately extinguished. Before the spoon is removed it should be dipped into the water below.

220. *Combustion of sulphur.*—Place in a platina or brass spoon, a small piece of sulphur, previously inflamed; immerse it in a jar of oxygen, and the combustion will be greatly increased in brilliancy—the whole jar showing the most vivid blue light. When the combustion is finished, the jar will contain sulphuric acid, which at first rises as a brown vapour, and is rapidly absorbed by the water; another instance of the formation of an *acid* by the union of oxygen and a simple substance. The currents of heated air, or rather the sulphurous fumes which arise from the burning mass, present a very singular appearance. A stream ascends to the top of the jar, and after rolling over descends near the outside of the jar in a nnmber of rings, quite distinct from the ascending current, as may be represented in the following cut, where A is a small stand holding the burning sulphur. B, the ascending current. C C, C C, C C, some of the descending rings.

221. *Re-kindles a nearly-extinguished fire.*—Project a stream of oxygen upon the smouldering embers of a fire nearly extinguished, it will immediately lighten it up afresh, showing that combustion is in exact proportion to the quantity of oxygen communicated to the combustible body. A piece of saltpetre thrown into a fire answers the same purpose, because of the oxygen it gives out in burning.

222. *Ignition of charcoal.*—Fasten to a wire a piece of charcoal, tying it with another bit of wire; hold it to a candle so as to ignite it in one speck only—immerse it in a jar of oxygen, and it will burn with the utmost beauty, forming, by the chemical action which takes place, carbonic acid gas; the oxygen uniting with the charcoal. For this experiment the charcoal should be near the bark of the tree, and of some light wood, as then brilliant sparks are thrown off.

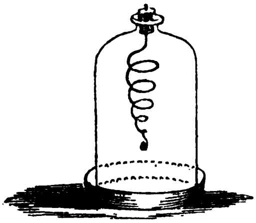
223. *Combustion of the diamond.*—The combustibility of the diamond seems first to have occurred to Newton. The burning of it by artificial means is thus described by Brande:—"When the diamond is heated in the flame of the blowpipe, it soon begins to burn, and the combustion continues as long as the temperature is sufficiently high, but it does not produce heat enough, during its combination with the oxygen of the atmosphere, to maintain its combustion. If while thus burning, it be introduced into a jar of pure oxygen, the combustion continues longer and sometimes till the whole is consumed: the best support for it in this experiment, is a small loop of platinum wire, or a very small and thin platinum spoon, perforated with many holes; in this it may first be intensely heated by the oxygen blow-pipe, and whilst burning, carefully immersed into a bottle or pure oxygen gas, containing a little lime

water; a good cork through which the wire of the spoon passes, should secure the mouth of the bottle; it will thus go on burning brilliantly for some time, and the formation of carbonic acid be shown by the milkiness of the lime water.

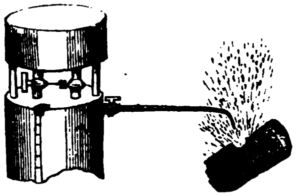
"The combustion of the diamond may be more perfected, by placing it upon a platinum capsule, in a jar of pure oxygen inverted over mercury, and throwing upon it the focus of a burning lens. It will continue to burn in the oxygen after being withdrawn from the focus, with so brilliant a light as to be visible in the brightest sunshine, and with very intense heat."—*Brande's Chemistry.*

For other methods of burning the diamond, see *Carbon.*

224. *Burning of a watch-spring.*—Procure a piece of thin steel watch-spring, 3 or 4 inches in length, fasten the upper end to a cork which fits a gas jar or bottle, stick a minute piece of phosphorous to the lower end of the wire; inflame the phosphorus, and while inflamed, dip the whole into the jar of oxygen, the brilliancy of the combustion will not only be amazingly increased, but the steel wire become so heated as to fly off in brilliant sparks; continuing to emit them till the whole wire is consumed. The result is an *oxyde* of iron, the oxygen having united to the iron, by aid of the great heat of the latter. When performing this experiment, some wet sand should be put at the bottom of the jar, in order to catch the melted particles, and the jar used should not contain less than a quart.



225. *Burning of iron nails.*—Fasten to the side orifice of the gas-holder, a blow-pipe, or if the gas-holder is not at hand, use a bladder of oxygen, having either a stop-cock and blow-pipe attached to it, or else a piece of tobacco-pipe tied tightly within the orifice. Take a large piece of charcoal, scoop a small hole in it, and hold it over the candle until the charcoal is lighted within or about the hole, then drop into it a small cast-iron nail, that called a *sparable*, answers exceedingly well; pour a stream of oxygen upon the charcoal, this will burn more rapidly, the nail will become white-hot, it will then be fused, and finally ignite and be dispersed in a large and brilliant shower of most vivid sparks. This is certainly one of the most beautiful experiments that science produces.



226. *Combustion of boron.*—If a small piece of boron be heated to 560° of heat in a deflagrating spoon, and introduced into a jar of oxygen gas, it will burn with the greatest brilliancy, and by combination with the oxygen will be converted into boracic acid. The affinity of boron for oxygen is so great at this temperature as to separate it from any other substance.

227. *Combustion of Homberg's pyrophorus.*—Pour into a jar of oxygen gas about a scruple of Homberg's pyrophorus. This inflammable substance will take fire the instant it enters the jar; the ignition will be accompanied by a slight explosion.

228. *Combustion of potassium.*—Into a small bottle of oxygen drop half a grain of potassium, previously heated to near a red heat; or it may be heated within the bottle by means of a burning lens. It bursts into flame, and becomes changed into a white powder, called the peroxyde of potassium, or better known as the *alkali* potass; thus showing that oxygen may communicate alkaline, as well as in the former experiments, acid properties.

229. *Combustion of tin.*—Heat some granulated tin considerably in a deflagrating spoon, and in this state immerse it in oxygen gas. A very beautiful combustion, attended with a brilliant white light, will instantly take place, when *oxyde* of tin will be formed.

230. *Combustion of zinc.*—If zinc filings or turnings be put in the spoon, together with a piece of ignited phosphorus, and in this state the spoon be immersed in a jar of oxygen, combustion will be soon communicated to the metal, which will burn with a blueish flame, and give rise to dense white fumes of *oxyde* of zinc.

231. *Combustion of arsenic.*—Put a small piece of metallic arsenic into the deflagrating spoon, with a piece of phosphorus, as in the last experiment. Set fire to the phosphorus, and introduce the spoon quickly into a jar of oxygen gas. The phosphorus will soon fire the metal, which will burn with much brilliancy, giving out white fumes of arsenious acid.

232. *Specific gravity of oxygen.*—Fill a bottle with oxygen gas; turn its mouth upward, and withdraw the cork. The gas will not escape, as may be tried by holding a lighted taper within the bottle; some time afterwards it will be found present, as at first. Hold this uncorked bottle in one hand, and a lighted match, or piece of lighted charcoal, in the other, and pour the oxygen upon the light, in the same manner as pouring wine into a glass. The oxygen will fall upon it, showing that it is heavier than common air.

233. *Its neutral properties.*—In a jar filled with oxygen, dip a strip of litmus paper, which will not be colored red; also a strip of paper tinted with turmeric, which will not be rendered brown. Thus proving oxygen gas to be neither acid nor alkaline, and yet oxygen is the chief cause of acidity and alkalinity.

234. *Stimulating effects of oxygen.*—Let a person inhale from a bladder two or three quarts of oxygen gas. His pulse will be raised forty or fifty beats per minute, and afterwards he will feel himself considerably elated, and have a greater inclination for muscular exertion—so by depriving common air of oxygen the pulse may be lowered. These facts have been taken advantage of in medicine, as may be seen by many papers in Tilloch's "Philosophical Magazine."

235. *Effect on a glow worm.*—Immerse a glow worm in a jar of oxygen gas in a dark room. The insect will shine with much greater brilliancy than it does in atmospheric air, and appear more alert.

236. *Colors of heated steel.*—Place the blade of a bright steel instrument in the flame of a candle; it will change, first, into a straw color, then progressively into brown and purple, and, finally into a bright blue, "which," as Brande says, "is because of the union of oxygen with the surface. Sword blades are rendered blue by subjecting them gradually to the heat of burning charcoal.

"These colors upon steel are proved to be the effect of oxidation, because, unless the steel be in contact with oxygen, the color is not produced; thus when steel is heated under the surface of oil, or in hydrogen gas, it remains with its previous polish; even rubbing it with grease will prevent the oxidation." [The above remark is in Brande's "Chemistry," but we rather doubt its correctness.—Ed.]

237. *Change of color in sulphur.*—Melt in any vessel upon the fire, some pieces of sulphur, after a little time it will become red, and afterwards brown and tenacious; which changes arise from the absorption of oxygen, although it is in so small a quantity as not to be appreciable.

If copper be melted, cast in ingots, and while still hot, plunged into water, it becomes of a fine red color externally. Thus we can explain the cause of the iridescence seen occasionally upon lead, zinc, and brass, when cast in damp moulds; and also upon the surface of many minerals, as sulphuret of iron, the peacock ore of copper, &c.

238. *Colors of metallic oxydes.*—Expose melted lead to the action of a stream of oxygen, and it soon becomes changed to a whitish grey powder, Continuing to blow upon it with oxygen, it will become first lemon, then orange colored, in which state it is called massicot, or the protoxide of lead; the still prolonged action of oxygen, the heat being continued, changes it to red lead.

239. *Coloring of gallates.*—Make a saturated solution either of potass, soda, or ammonia, with pure gallic acid, so as to form a neutral gallate; it will be found colorless, but pour some of the solution into a phial of oxygen, shake it up, and it will become of a deep brown color.

240. *Restoration of the color of litmus.*—The tincture of litmus, if long kept, often becomes colorless; if in a phial containing some of this discolored liquid a small quantity of oxygen be inclosed and shaken up, it will unite with the liquid, and become instantly of its original blue tint.

241. The spirits of wine in thermometer tubes when colored at first by litmus, soon becomes white or lemon colored; if the tube be broken, the liquid thus exposed to the oxygen in the air regains its original color; thus showing that it is not light which occasions the change.

242. *Restoration of the color of faded silks, &c.*—Shut into a dry phial along with oxygen gas, a piece of damp faded silk, print, or paper, which has been dyed with any vegetable infusion, such as indigo, archil, madder, &c.; it will imbibe the gas, and be restored to all its original brilliancy.

Note.—The above experiment is uncertain in its result, because of the mordants employed in dyeing; it also generally requires some days before perfect success is ensured.

243. *Bleaching effects of oxygen.*—Place upon a piece of stuff, silk, &c., dyed with indigo, any substance which readily absorbs oxygen, such as potassium, and it will become green. By its after exposure to the air, or to a stream of oxygen, it again turns to blue as at first. By a process of this kind indigo is rendered perfectly white.

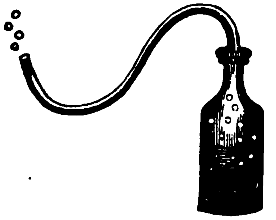
The peculiar combinations of oxygen, with the other elements, will be treated of in succeeding articles, either in connection with each particular base, or under the distinct heads of oxydes, alkalis, earths, acids, &c.

HYDROGEN.

Hydrogen was first obtained pure by Mr. Cavendish in 1766. It is a colorless gas, permanently elastic, without taste, and when perfectly pure without smell. It is the lightest body known, being sixteen times lighter than oxygen, or thirteen times lighter than atmospheric air, its specific gravity being 0·0694, and 100 cubic inches of it weighing 2·118 grains. It cannot support combustion or respiration; but is itself in an eminent degree inflammable, requiring however oxygen to support the combustion; it may be set fire to by any material made red-hot, it explodes when mixed with oxygen or the atmospheric air, forming water, and its heat when burning is greater than that of any other material.

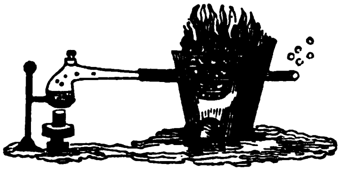
Ex. 244. *To procure hydrogen from iron, sulphuric acid, and water.*—Put into a wine bottle, a few iron nails, add some water, and then sulphuric acid equal in quantity to one-fourth of the water; the iron nails will in a minute or two be covered with bubbles of gas, which will rise to the top of the vessel. Hold a candle near the gas as it passes away from the mouth of the bottle, and by its taking fire it will be known to be hydrogen. It may be collected either with a bent tube passing under the shelf of the pneumatic trough, or by a bladder fastened to the mouth of the bottle. (*See Cut.*)

In this experiment the water is decomposed, its oxygen unites with the metal as it is acted upon by the acid, and the other constituent of the water, viz. hydrogen, being light, escapes upwards. One ounce of iron yields 782 cubic inches of gas. On account of the great ebullition which ensues, the vessel should not be more than one-third full.



245. *To procure hydrogen from zinc, sulphuric acid, and water.*—Use some pieces of zinc, cut small, instead of the iron in the last experiment, and a tolerably pure hydrogen will be rapidly liberated—it may be collected as before. This gas is often called hydrozincic gas, it holding minute portions of zinc suspended in it. One ounce of zinc yields 676 inches of gas. It is produced more rapidly in this manner than in the former.

246. *To procure hydrogen from water.*—Pass an iron tube or gun barrel, open at both ends, through a fire. Make it red hot, and to one end fasten a retort holding water,—make this water hot, by a lighted lamp being placed under the retort, so that the steam may pass through the red hot iron tube. In this transit it will be decomposed, the oxygen being absorbed by the iron, rendering that an oxyde, while the hydrogen passes through, and may be collected at the other end of the tube, which ought to dip under the surface of water that the gas may be cooled and purified.



247. A porcelain tube, filled with ignited charcoal, will no less decompose water, liberating the hydrogen; but in this experiment, carbonic acid gas arising from the charcoal also passes over, and thus contaminates the gas, until by long contact with water, the carbonic acid is absorbed, and the hydrogen remains.

248. *To purify hydrogen.*—The gas obtained by the former experiments is never perfectly pure. To render it so, and which is necessary for delicate experiments, it must be passed through a solution of potass, then dried by passing it through a tube containing fragments of fused chloride of calcium, (muriate of lime.) The hydrogen procured by the decomposition of water by galvanism is considered perfectly pure.

249. *Hydrogen destructive to animal life.*—Drop a small animal into a jar of hydrogen, and it will be instantly deprived of life. This appears to arise not from any deleterious property of the gas, but merely owing to the non-existence of oxygen, as mixtures of hydrogen and oxygen are respirable.

250. *Effect on the voice when inhaled.*—Fasten a large mouth piece or wide tube to a bladder, filled with hydrogen gas, put it to the mouth, and stopping the nostrils, inhale only the hydrogen, and the voice will become shrill, and then be completely lost for a short time. This is supposed to arise from the extreme tenuity and lightness of the gas, it not having sufficient momentum to effect the organ of voice.

251. *Gilding silk, ivory, &c., by hydrogen.*—Immerse a piece of white satin, silk, or ivory, in a strong solution of nitro-muriate of gold. While this substance is still wet,

immerse it in a jar of hydrogen gas, it will after some time be covered by a complete coat of gold. The hydrogen in this experiment decomposes the oxyde of gold, which is the base of the salt, appropriating to itself the oxygen, and suffering the gold to be deposited in a metallic state.

252. *Producing gilt flowers, &c., on silk or ivory.*—The foregoing experiment may be varied as follows; paint flowers, &c., on the silk, with the nitro-muriate of gold, and the aid of a very fine camel-hair pencil. Hold the silk thus painted over the bottle in which hydrogen is being liberated; in a short time, the flowers will shine with considerable brilliancy, and will not tarnish upon exposure to air. The thickness of the coating of gold is not more than the 10 millionth part of an inch.

253. *Silvering by hydrogen.*—Immerse a white silk ribbon in a solution of nitrate of silver, and while wet expose it to a stream of hydrogen. The silver will be reduced to a metallic state on the silk. This may be varied, as in the preceding experiment. The same effect takes place with platinum, but not with any of the other metals, because all the others hold the oxygen contained in their oxydes too tenaciously for hydrogen to decompose them.

254. *Inflammability of hydrogen.*—Drop into a common wine bottle an ounce of iron nails, pour upon it sulphuric acid, with 4 parts water. Through the centre of a cork which fits the bottle insert a tobacco pipe stem; the gas which issues from the ingredients within the bottle will ascend through the pipe and escape. If a light be applied to the gas as it passes out, it will catch fire, and burn with a dull yellowish flame, continuing ignited as long as the ingredients afford it in sufficient quantity. It is advisable to let the first portions of the gas escape, that they may carry off some of the air in the bottle. This has been called the *philosophical candle.*

255. Hold over the bottle in which the gas is forming, a long tube, stopped at the upper end, which will soon be filled with the gas; wrap a handkerchief round this tube, merely to defend the hand, and without turning it up,—that is still with its open end downwards; set fire to the contents, a dull explosion takes place, and the hydrogen is seen to burn away slowly upwards, as each part when consumed permits the air to come in contact with the next.

256. *Hydrogen soap bubbles.*—Blow some soap bubbles, filling them from a bladder of hydrogen, furnished with a brass pipe; they will ascend rapidly to the ceiling; if they are intercepted in their course by a lighted candle they will explode with a dull report, and a flash of yellow light.

257. *Oxygen necessary for its inflammation.*—Let a shred of potassium fall into a bottle containing *only* hydrogen, and a little water, and the gas will not take fire. This may easily be tried in the bottle in which hydrogen is being formed, but if a portion of common air be present, explosion ensues, therefore great caution is necessary in performing the experiment.

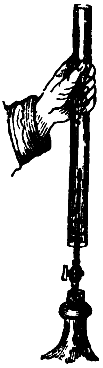
258. *Not a supporter of combustion.*—Into a jar of hydrogen immerse suddenly a lighted taper, and although the gas itself will be inflamed, the flame of the taper will be extinguished, and by no methods can it be thrust down into the gas, and remain alight, showing that though combustible, hydrogen is not a supporter of combustion.

259. *Oxygen appears to burn.*—Fasten to the top of a bottle, where hydrogen gas arises, a tube of glass, shaped like a syphon, one leg of which may be about an inch or an inch and a half in diameter; place the tube so that this leg may hang down parallel to the bottle, that the gas may only issue into the atmosphere at the lower end. Being lighted, it will, if the gas be abundant, continue to burn quietly without the flame ascending into the tube itself. While thus burning, thrust into the flame, and through it into the body of the gas above, a fine tube from which oxygen is issuing very slowly, the jet of oxygen will appear to burst into flame immediately it comes near, and to burn in the midst of the hydrogen.

This is a very singular experiment, and it would appear as if the oxygen were the combustible, and the hydrogen the supporter of the combustion; but the fact is, that hydrogen burns in the midst of hydrogen, without inflaming that around it, the combustion being supported only where it meets with the oxygen, thus it burns in a film of exactly the shape of the jet issuing into it. If the jet of oxygen be not extremely minute, an explosive mixture of the two gases is very liable to be formed.

260. *Effect of water on burning houses.*—Water thrown upon a house when on fire, if not in over-powering quantity adds to the mischief, as the great heat decomposes it; its oxygen and hydrogen both aiding the combustion.

261. *Light and heat of inflamed hydrogen.*—In the above experiments, where hydrogen burns, the flame is blueish or yellowish, and so faint, as in daylight to be scarcely visible; it is however intensely hot. To test this, hold a fine rod of glass to the point of the flame, and it instantly becomes red hot, and may be blown or beaten to any shape; a candle, piece of paper, &c., instantly takes light if held to the fine jet of burning hydrogen.



262. *Musical sounds produced.*—If when the gas is inflamed at the end of a fine tube, a larger tube of glass or earthenware about 2 feet long, be held over the flame in the manner represented, musical sounds will be produced by the vibration of the larger tube. These sounds are varied according as the tube is raised or depressed, and also tubes of different sizes will produce different tones. This curious effect is not peculiar to hydrogen. The flame should be extremely small, therefore a brass tube with a stop cock is much preferable to a tobacco pipe. This effect of producing sound is owing to the rapid mechanical action of the gas in a state of combustion; for the newly-formed product (the steam produced by union of the hydrogen gas and the oxygen of the atmosphere,) being held in a state of vapor until the cool sides of the tube and the surrounding atmosphere deprive it of its caloric, fills up a certain space; but when this space is evacuated by departure of the caloric, and the consequent condensation of the liquid, an equal portion or bulk of common air rushes in to supply its place. Thus, by a rapid condensation and succession of currents of air, vibration is caused in the tube,—and this vibration produces the sound.

263. *Lightness of the gas.*—Fill a jar with hydrogen, and let it stand for a few moments with its open mouth upwards, and letting down a taper into it, the gas will be found to have escaped. Put another jar filled with its mouth downwards, the gas will now remain much longer than before, being prevented from escaping by the top and sides of the vessel.

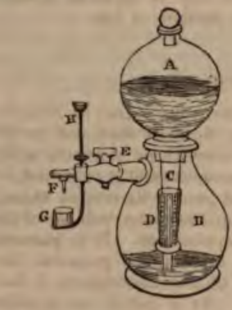
264. Provide an air jar with a stop cock and jet, and fill it with hydrogen upon the shelf of the pneumatic trough: then set fire to the gas at the jet, and, whilst it is there burning, slowly lift the jar out of the water, holding it by the brass cap. The flame will continue for some time at the jet, the hydrogen being propelled through it by its lightness, but when the air becomes mixed in such proportions with the gas as to form an explosive mixture, the flame recedes through the jet, and the whole kindles suddenly. The jar should be long and narrow.

265. *Shown by a balloon.*—Procure a small balloon, made of the craw of a turkey, or of gold-beater's skin, and fill it with hydrogen; tie the mouth and let it escape, it will soon mount to the ceiling of the room, or if in the open air fly out of sight immediately.

266. *Effect upon spongy platinum.*—When a stream of hydrogen is projected from a gasometer or bladder upon a piece of spongy platinum, which is metallic platinum in a minute state of division; it immediately becomes incandescent if atmospheric air or oxygen be at the same time present, and the hydrogen is almost instantly inflamed. The spongy platinum must be well dried previous to using.

267. *Dobereiner's lamp.*—Upon a knowledge of this fact, which was discovered by Dobereiner, Gay-Lussac constructed an ingenious instrument for procuring instantaneous light, by which a jet of hydrogen can be obtained by merely opening a stop cock; a brass cap being fixed below it to receive the platinum. A is a glass funnel closed at the top, and connected with the pipe C below, it fits the under vessel by a ground glass joint. The vessel B has a brass appendage on the side of it, consisting of a cock E, a jet F, a sliding wire H, and a cup for the platinum G. D is a cylinder of zinc put round the stem C. When sulphuric acid and water are poured in, gas is generated; it occupies the upper part of B, and as it cannot escape, the cock E being closed, it by its pressure drives the liquid in B up into the vessel A, and D becoming uncovered, no more gas is

liberated; but when the gas issues from F, the liquid in A descends, again covers the zinc, and affords a fresh supply of gas. The gas from F falls upon the platinum in G and renders it red hot, the heat of this inflames the gas, and thus produces a light instantly.



NITROGEN.

This gaseous element was discovered by Dr. Rutherford, of Edinburgh, in 1772; and its principal properties ascertained by Lavoisier, who discovered that it constituted four-fifths of the air of the atmosphere. He gave it the name of *azote*, signifying without life, from the inability of the gas to support respiration, or combustion. It is sparingly soluble in water; this liquid taking up when boiled about 1½ per cent. of nitrogen. It is singularly inert in its action upon the other elements. It is called nitrogen, because it is an element of nitric acid. It is tasteless and colorless, and has never been liquefied; it is rather lighter than atmospheric air, consequently it will escape out at the top of a jar if left uncovered.

Ex. 268. *To procure nitrogen.*—Attach a small piece of wax taper to a cork; light the taper, float the cork in a deep plate, full of water, and while the taper is burning cover it over with a glass receiver. It will be seen, that the light of the taper will become dimmed, and in a short time go out. This is because it has consumed all the oxygen of the air that was in the jar; what is left is nitrogen, mixed with some carbonic acid. It may be deprived of this latter by using lime water to stand the jar in, instead of common water. There must also be enough water that it may rise in the jar, according as the combustion goes on. The taper does not consume quite all the oxygen in the jar, but so nearly all that the nitrogen is sufficiently pure for ordinary experiments.

269. Put a little lime water into a collapsed bladder, without suffering atmospheric air to enter the bladder; blow into it with the mouth until expanded, agitate the bladder well, and the contents will be found to be nitrogen. The use of the lime water is to absorb the carbonic acid gas, which forms part of the air expired from the lungs.

270. *To procure nitrogen from phosphorus.*—The best way of preparing nitrogen gas is by burning phosphorus in atmospheric air, included in a jar or bottle over water. For this purpose, a small saucer of tinned iron, or a brass stand with a copper cap fixed to the top, as represented in the annexed figure, is placed on the shelf of the pneumatic trough, and covered with a bell-glass the moment the phosphorus is kindled by touching it with a small iron wire previously heated. A large quantity of white fumes is produced, which are speedily absorbed by the water, while nitrogen alone remains in the gaseous form.

271. *To procure nitrogen from chlorine and ammonia.*—Procure an apparatus similar to the following:—The open pipe at the side is supposed to be the beak of a retort in which chlorine is being disengaged. It enters the globular receiver and deposits condensed vapors. Then passing along the bent tube, it arrives at the bottle B, which is partly filled with diluted liquid ammonia; passing through the ammonia, it is conveyed away by the pipe C into the jar D.

In this experiment, "ammonia, consisting of hydrogen and nitrogen, is decomposed by the chlorine, which unites with its hydrogen to form muriatic acid, and gaseous nitrogen is evolved. A solution of chloride of ammonia is at the same time obtained; and if excess of chlorine be used, chloride of nitrogen, which is a very dangerously explosive compound, may be formed. If the ammoniacal solution be very concentrated, the bubbles of chlorine often produce flashes of light and slight explosions; these are quite harmless, and may be prevented by dilution of the ammonia."—*Brande.*

272. According to Berzelius, the purest nitrogen is obtained by filling a bottle about one-third full of a liquid amalgam of lead and mercury, carefully stopping it, and agitating it with the included air for two hours, or more; the finely-divided lead absorbs the oxygen, and leaves pure nitrogen. On opening the phial under water, the liquid rushes in, and demonstrates the degree of absorption.

273. A mixture of equal weights of sulphur and iron filings, made into a paste with water, rapidly abstracts the oxygen of the air in contact with them, leaving the nitrogen nearly pure. The experiment is to be performed thus:—After mixing the substances, heat them over the fire until of a black color, and warm. Then put them into a tin cup, float this cup upon the surface of water in a basin, cover it with a gas jar, and suffer it to remain untouched for 48 hours; at the end of that time the oxygen of the air will have been absorbed, and scarcely any thing but nitrogen remain.

274. Wash a piece of beef well, and cut it into very small pieces; put these into a retort and place them over a lamp. Now pour in some diluted nitric acid, and insert the beak of the retort under a receiver standing on the shelf of a pneumatic trough. Nitrogen gas will come over and fill the jar.

275. *Does not support animal life.*—If a small animal be dropped into a jar of nitrogen, it will fall down gasping for breath; and not being able to inspire the gas will die in an instant. It does not appear that nitrogen has in it any thing deletereous to occasion loss of life to the animal; it dies merely because there is no oxygen present, the same as it would under the exhausted receiver of an air pump.

276. *Does not support combustion.*—To show that this gas will not support combustion, any substance may be introduced into it in a state of combustion, when it will be immediately extinguished.

277.—If two jars are taken, one full of oxygen, and the other full of nitrogen gas; a suspended taper introduced into the nitrogen is immediately extinguished; but if it has previously been allowed to burn till the wick is red, and the least red spark remain on withdrawing it from the nitrogen,—it will be rekindled on transferring it quickly to the jar of oxygen gas, and again extinguished in the nitrogen; this may be repeated several times in the same portions of gas.

CHLORINE.

A gaseous element discovered by Scheele in 1774. It was formerly supposed to be compounded of oxygen and muriatic acid. Sir H. Davy however showed it to be a distinct element, and gave it its present name, chlorine, which signifies green, because of its yellowish green appearance. It is gaseous only at common atmospheric pressure, for under the weight of four atmospheres it becomes a liquid. As a liquid, its specific gravity is one-third greater than that of water, as a gas it is 2½ times the gravity of air; 100 cubic inches weighing about 76 grains. It is unattended by a high temperature. It is soluble in cold water, is highly deleterious if inhaled, pungent in odour, a powerful antiseptic and destroyer of contagion, bleaches all vegetable colors, and although not properly speaking a true supporter of combustion, yet it unites with so much rapidity with certain bodies, that flame and scintillation are the consequences.

Ex. 278. *To make chlorine.*—Put into a glass retort a mixture of 8 parts of common salt, 3 of pulverized binoxyde of manganese, 4 of water, and 5 of sulphuric acid. Apply the heat of a lamp and the gas will rapidly pass over. If a dry bottle be placed under the beak of the retort, the gas will fall into the bottle, and thus any number of bottles full may be collected.

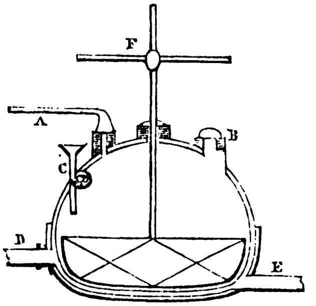
279. Thenard recommends the following proportions:—4 parts of salt, 1 part of black oxyde of manganese, 2 each of sulphuric acid, and of water.

280. Another process for preparing chlorine consists in mixing 43·7 parts of the binoxyde of manganese, intimately with 59 of chloride of sodium (common salt) in a mortar, and pouring over the mixture 98·2 parts of sulphuric acid, previously diluted with half its weight of water, and allowed to cool—3 or 400 grains of salt will be sufficient for ordinary experiments.

281. Put into a glass retort 1 ounce of the black oxyde of manganese, and as much hydrochloric acid as will make it of the consistence of thick cream, (about 2 ounces.) Mix the two together, and applying the heat of a lamp, the gas will come over copiously.

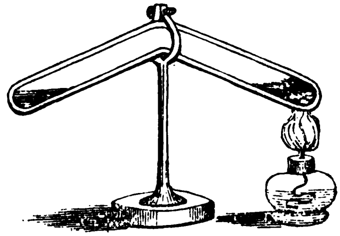
The pneumatic trough may be used in the making of chlorine, if filled with hot water, and provided the gas is not allowed to stand too long over the water; in which case much of it would be absorbed. The retort should not be more than half full at first, and great care must be taken not to suffer the gas to enter the mouth or nostrils, as when breathed it produces an extremely irritating effect upon the lungs—a single inspiration occasioning violent coughing, difficulty of breathing, &c., for several days; and sometimes if the gas be in considerable quantity, a falling down in a dangerous state of insensibility.

282. *To make chlorine in large quantities.*—" A somewhat different process for the preparation of chlorine is generally followed on the large scale. About 6 parts of manganese, with 8 of common salt, are introduced into a large leaden vessel, of a form nearly globular, (as represented in the figure,) and 5 or 6 feet in diameter; and to these are added as much of unconcentrated sulphuric acid as is equivalent to 13 parts of strong oil of vitriol. The leaden chamber is placed in an iron pan, or has an outer casing D E; and to heat the materials, steam is admitted by D into the space between the bottom and outer casing.

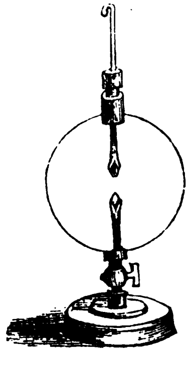


" In the figure, which is a section of the leaden retort, A represents the tube by which the chlorine escapes. B a large opening, for introducing the solid materials, covered by a lid or water valve, from the edges dipping into a channel containing water. C a twisted leaden funnel for introducing the acid. F a wooden agitator, and E a discharge tube, by which the waste materials are run off after the process is finished. A retort of lead cannot be used with safety with binoxyde of manganese and hydrochloric acid for chlorine, owing to the action of the acid upon the lead, and the evolution of hydrogen gas, which produces a spontaneously explosive mixture with chlorine."—*Graham's Chemistry.*

283. *Liquefying of chlorine.*—Put some of the materials from which chlorine may be extracted, as above given, into a tube shaped and supported as under, and let it be hermetically sealed. When the materials have been poured in, keep one end of the tube as cold as possible, and apply heat at the other end. Chlorine will of course be formed, but having no egress it will become compressed. When the pressure amounts to four atmospheres, the gas will lose its gaseous form, and will be seen to trickle down the other end of the tube, appearing as a thin yellow liquid. If the tube be broken, it will suddenly expand into a gas. It perhaps is not necessary to observe, that the tube must be a very thick one, and able to sustain a considerably greater pressure than that it will be subjected to in the course of the experiment, otherwise danger may ensue.

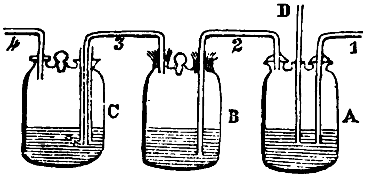


284. *Chlorine not affected by a high temperature.*—Procure a glass globe or other vessel, with two orifices. Let a wire pass, by means of a cork, or otherwise, through each orifice, and let the wires be tipped with charcoal. Then fill the vessel with chlorine gas, and adjust the wires, so that their points shall nearly touch each other. When the electric current is made to pass through the wires, the charcoal points will be ignited, becoming of a red heat, yet the chlorine will not be affected, however long the action may be pursued.



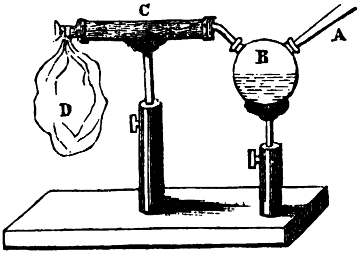
285. *Impregnating water with chlorine.*—For this purpose nothing further is necessary on common occasions than to pour some

distilled water into a jar, or large phial, containing chlorine, and to agitate them together. The solution of chlorine will be of a greenish yellow color. When chlorine and water are left in contact a slow absorption of the gas takes place. The most elegant method of impregnating water with an absorbable gas is by means of a Woolf's apparatus—one of which is represented beneath. The gas issues from a retort by the pipe 1; it passes into the water of the vessel A, and is absorbed—when the water in this vessel is saturated, the gas passes to the next vessel B, through the pipe 2, which dips beneath the water of B. This being saturated, the superabundant gas passes to a third vessel C, and so on to any extent that may be required. For a simpler apparatus, see *Carbonic Acid Gas and Sulphuretted Hydrogen.*



286. *To render chlorine perfectly dry.*—The drying of chlorine and other gases may be done in two ways—one by suffering it to pass through strong sulphuric acid, which having a very great affinity for water will rapidly absorb any moisture which may come over along with the gas. This may be done with a small gasometer, made of two glass jars; or it may be dried by having an intermediate vessel, filled with the chloride of calcium, (muriate of lime,) and letting the gas come in contact with the chloride, as represented below:—

Instead of the round vessel, depicted in the cut as the intermediate vessel holding the salt, a tube united to the retort at one end and to the gas-holder at the other, is greatly to be preferred. This tube should be not less than a foot in length and an inch in diameter, and be nearly filled with the chloride. The following engraving may illustrate the manner of attachment, and position of the tube. A being the beak of the retort. B a vessel, to catch any water which may condense. C the tube, filled with the chloride; and D a bladder to receive the dried gas.



287. *Does not sustain animal life.*—Place a mouse, or other small animal, under a jar of chlorine, or drop it into one from the aperture at the top of a jar filled with this gas. The animal will instantly fall dead. The effect of inhaling a less portion than what is sufficient .to destroy life has before been shown.

288. *Prevents putrefaction, and destroys offensive effluvia.*—Place a piece of tainted meat, fish, or other putrifying substance into a jar of chlorine, or sprinkle it with aqueous chlorine; the whole of the noxious effluvia will be very rapidly destroyed; also, if chlorine applied either in the state of fumes, or as a liquid, to meat, &c.—while fresh putrefaction will not take place at all. It also rapidly destroys the miasmata arising from contagious disorders, and is thus valuable in fumigation.

289. *Fumigating apartments, &c.*, may be done by placing in each apartment a saucer filled with any of the before-mentioned combinations of ingredients, placing the saucer over a basin of hot water. It is most conveniently performed by using a salt of chlorine, such as the chloride of lime, of which a small quantity may be mixed with water in a hand-basin, and an equal quantity of hydrochloric acid poured upon it. The gas is evolved from these materials without heat.

290. *Morveau's preservative phial.*—The portable phial, contrived by Morveau for preventing contagion, may be thus prepared, its preservative effects arising from the extrication of chlorine; 46 grains of black oxyde of manganese, in coarse powder, are to be put into a small, strong, glass phial, with an accurately-ground stopper, to which must be added about ¼ of a tea-spoonful of strong nitric acid, and an equal quantity of strong hydrochloric acid. The stopper is then to be replaced, and the whole secured by inclosing the phial in a strong wooden case, with a cap which screws down to keep the stopper safe.

It is to be used in hospitals, sick chambers, or other places of infection, by simply opening the phial, at arm's length, and letting it remain at that distance until the smell of the chlorine is perceived, when the phial is again to be closed. A phial of this kind, properly prepared, may be used several years without losing its effect. The mixture, however, ought not to occupy more than ⅓ of the bottle.

291. *Bleaching vegetable infusions.*—Make a solution of litmus, indigo, or other vegetable coloring matter, and suffer chlorine issuing from a small tube to pass into the phial containing the solution. In a minute or two the color of the solution will be completely destroyed.

292. *Bleaching of flowers.*—Place a nosegay of various flowers under a bell-shaped gas jar, and suffer perfectly dry chlorine to pass into the jar. If the flowers be also dry the chlorine will appear to have little effect upon them; then dip the flowers in water, shaking them till the superabundance of water has left them, so that they shall be merely damp. Suffer chlorine to enter the jar, it will be rapidly absorbed by the flowers and leaves, bleaching them of a perfectly white color. Some flowers part with their color much more readily than others. The effect is most remarkable, as we may see roses, pinks, lilies, and other flowers all of the same hue.

293. *Bleaching cotton goods* is performed by the aid of chlorine: it is done as follows:—The cloth, after being well washed, is boiled first in lime water, and then in caustic soda, which removes from it certain resinous matters, soluble in alkali. The bleaching process then begins:—It is steeped in a solution of chloride of lime, so dilute as just to taste distinctly, which has little or no perceptible effect in whitening it; but the cloth is afterwards thrown into water acidulated with sulphuric acid, when a minute disengagement of chlorine takes place throughout the substance of the cloth, and it immediately assumes a bleached appearance. The operation is usually repeated to procure an absolute whiteness. Finally, the goods are well washed in warm water.

294. *Effect on a burning taper.*—Plunge an ignited taper into a jar of chlorine gas: its flame is extinguished, but the column of oily vapor rising from the wick is re-kindled by the chlorine, and continues to burn with a red and smoky flame, which expires on removing the taper into the air. The combustion is sustained by the chlorine combining with the hydrogen of the inflammable matter, while the carbon is precipitated.

295. If a candle, with a large wick, and that red hot, be introduced into a jar of chlorine gas, it is rekindled so as to burn with flame. This would appear contrary to the last experiment; the difference is, that in this the wick is still able to decompose the tallow or wax, and the oleaginous fumes passing into the chlorine become inflamed. That this is the true cause is proved by the following experiment:—

296. *Inflammation of spirits of turpentine.*—Pour some spirits of turpentine on the lower part of a piece of thin paper, folded in the form of a match. Allow any excess to drop off, and then put it into a bottle of chlorine, holding it with a pair of pincers. The spirits of turpentine will immediately take fire, and burn with a lurid flame, carbon in the state of a dense smoke being deposited.

297. *Combustion of charcoal.*—"Pour some dry charcoal, newly made and finely powdered, into a jar containing chlorine gas; a very beautiful combustion will take place, displaying a stream of fire."—*Mackenzie.*

298. *Spontaneous combustion of phosphorus.*—If a bottle be filled with chlorine gas, and a bit of phosphorus be introduced into it, it will take fire spontaneously, burning with a light green flame, but without affording so much light as in oxygen gas. The product will be a white substance, which adheres to the sides of the vessel, and is the protochloride of phosphorus. The protochloride is that state of combination in which the phosphorus unites with the least quantity of chlorine.

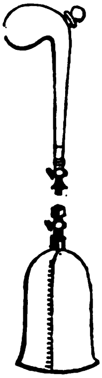
299. *Boron is combustible in chlorine.*—If a small quantity of boron be introduced into a bottle filled with chlorine, it takes fire, and burns with a most brilliant flame; and as the combustion goes on, the chlorine and boron are deposited on the sides of the vessel in the form of chloride of boron.

300. *Mercury burns in chlorine.*—A very brilliant combustion takes place if mercury, in a platinum spoon, be heated in a jar of chlorine. Chloride of mercury will be formed.

301. *Potassium burns in chlorine.*—Put a globule of potassium into an iron spoon, and immerse it in a jar containing chlorine gas; heat the potassium by means of a burning glass to about 70° of Fahrenheit; a very splendid combustion will take place, and chloride of potassium will be formed.

302. *Sodium burns in chlorine.*—The experiment may be varied by using sodium, which will give out flame and red sparks. The product will be chloride of sodium, or common salt.

302. ***Silver and gold leaf burn in chlorine.***—Put a piece of silver or gold leaf on the hooked end of a platinum wire; heat it to about 80° or 100°, and in this state immerse it in a jar of chlorine. Combustion with a brilliant white flame from the silver, and green flame from the gold will take place, and the chloride of one or the other metal be formed. Brande remarks, "that the most elegant way of making these experiments consists in introducing metallic leaf into a retort, mounted with a stop cock, and exhausted upon the air pump. It is then screwed into the cap of an air jar of chlorine, also mounted with a stop cock, and standing over water. Upon opening the cocks, the gas rushes into the retort, and the metallic leaf immediately burns. In consequence of their irregular thickness and form, retorts are often broken by the air's pressure whilst exhausting; so that it is safe to cover them with a cloth during the process to prevent the splinters being thrown about."



303. *Tin burns in chlorine.*—Put some granulated tin, or tin filings, heated to about 100° into a deflagrating spoon, and immerse them in a jar of chlorine. Immediate combustion attended by a *blueish white* flame will be the result. This experiment may be varied by immersing a piece of tin-foil, hung upon a platinum wire, in a jar of this gas.

304. *Bismuth burns in chlorine.*—Put a few bismuth filings into a platinum spoon; heat them to about 80°, and immerse them in a jar of chlorine. Combustion will take place, attended by a *blue* light. Chloride of bismuth will be formed.

305. *Arsenic burns in chlorine.*—Procure a jar of chlorine—the jar having an open top. Heat some filings of arsenic to such a degree of heat that they may feel hot to the fingers. Sprinkle a few of them in the jar; they will, in falling to the bottom, burst into a flame of a *green* color, attended by beautiful scintillations. Chloride of arsenic will be formed in dense white fumes.

306. *Iron burns in chlorine.*—Put some iron turnings into a platinum spoon; heat them to about 200° of heat, and immerse them in chlorine. Combustion, attended by a vivid *red* light, will take place, forming chloride of iron. These experiments may be varied in the manner of *Ex.* 302, producing very brilliant and varied effects.

307. *Cobalt burns in chlorine.*—Put some cobalt filings into a platinum spoon; heat them over the fire or a candle to about 200°, and immerse them in chlorine. Combustion, with a *pale blue* light, will be the consequence.

308. *Antimony burns in chlorine.*—Drop into a jar of chlorine some filings of antimony, heated to about 80°, rapid scintillating combustion will take place, attended by a *white* flame.

309. *Other metals burn in chlorine.*—Similar experiments may be performed with most of the other metals, giving various colored flames. Lead gives a white color; copper a dull red; and tellurium a green. These metals must be heated previously to immersion in chlorine, and although a very low degree of heat is sufficient for some, as lead and zinc, yet the combustion is much more vivid, if they be made still hotter; for instance, the more fusible metals so hot that they can be just held in the fingers without burning them, and the more refractory metals till they change color by heat. The jars used should be rather tall and narrow, for those experiments where the powdered metal is sprinkled in.

310. *Combustion of bronze powder.*—The metallic bronze powder, if heated, and poured a small portion at a time into a tall jar of chlorine, gives a most beautiful illustration of the union of chlorine with a metal, for as it falls through the gas in the jar, it appears like a complete shower of fire.

The compounds of chlorine are *Chlorides*, which see.

FLUORINE.

An elementary substance, contained in the mineral called Derbyshire spar, and a few other minerals. It has never yet been obtained in a perfectly pure state; some chemists believing it a liquid—others a gas. It is said when pure to be of a yellowish color, with an odour similar to chlorine. It destroys vegetable and animal coloring matters, and is similar in its general chemical relations to chlorine, iodine, and bromine. The following method is given in Dr. Reid's "Chemistry," for disengaging fluorine in some degree of purity, though by no means in a perfect or uncombined state:—

Ex. 311. "Heat, (in a leaden or silver retort) a mixture of fluoride of calcium (Derbyshire spar,) and binoxyde of manganese, with aqueous sulphuric acid. The aqueous sulphuric acid and the binoxyde produce sulphate of manganese and oxygen; with the fluor spar the sulphuric acid forms sulphate of lime and hydrofluoric acid. The liberated oxygen is supposed at the same time to attract hydrogen from the hydrofluoric acid, the fluorine being thus disengaged."

The compounds of fluorine are called *Fluorides*, which see.

BROMINE.

A reddish brown liquid, of fœtid odour, about three times the weight of water, which crystallizes into a brittle solid by cold, and is rendered gaseous by a heat of 116°. It dissolves sparingly in water, and has most of the properties peculiar to chlorine.

Ex. 312. *To procure bromine.*—Procure some sea water, boil it until the salt is deposited; continue the process till no more salt is to be procured, and save the remaining water, and which is called *bittern*, or mother water. Put this liquid in one or more of Woolf's bottles, as shown in *Ex.* 285, and suffer gaseous chlorine to pass through them. This will occasion the bittern to have an orange tint; the color arising from bromine which is separating from the bittern. When the liquid is of a full orange color, put it into a retort, and distil it; the bromine will pass over in the state of vapor into the receiver, where it is condensed into a liquid of a brownish red color.

313. *To make æthereal solution of bromine.*—Instead of distilling the orange-colored liquid of the last experiment, mix with it a small quantity of sulphuric ether; shake these two fluids together, and the ether will dissolve the bromine, and float above the water, appearing of a rich, reddish blue color.

314. *Second method.*—Put into a retort some bittern, as before mentioned; and add to it a little of the binoxyde of manganese and sulphuric acid. Distil in a glass retort, and the bromine will be liberated *before* the liquid boils.

315. *Alcoholic solution of bromine.*—Take any quantity of the chloride of bromine; add barytes to the liquid, evaporate the liquid to dryness, and add alcohol; this will dissolve the bromine. The alcoholic solution is often used in medicine.

316. *Bleaching properties.*—Hold a flower or leaf by a wire, opposite the top of a flask, whence bromine is being emitted, or wash it over with a pencil dipped in liquid bromine. It will very soon extract the whole of the color. The fumes of bromine are of an orange red color.

317. Into a jar of bromine suffer a small animal to fall, and its life will immediately become extinct.

318. Place a single drop of bromine upon the beak of a bird, it will be instantly killed.

319. *Crystallizes with water.*—Expose liquid bromine, mixed with a small quantity of water, to a temperature of 32°, the freezing point of water; or, in other words, place it in a thin glass test tube, and surround the tube with ice or snow. The bromine will assume the form of beautiful, red, octahedral crystals; this is a true hydrate of bromine. These crystals dissolve at a temperature of 50°.

320. Expose liquid bromine to a temperature of 15° below zero. It will freeze into a mass of a leaden grey color, and considerable lustre.

321. *Does not support combustion.*—Immerse a burning taper into a jar of the vapor of bromine; the flame will assume a dull red and green tint, and be speedily extinguished.

322. *Potassium spontaneously inflames.*—Suspend a grain of phosphorus to a wire, and immerse it in a jar of the vapor of bromine; it will immediately burst into flame.

323. *Metals melted.*—Drop into a jar of the vapor of bromine a few grains of powdered tin, and the particles of metal will become incandescent, and resemble a shower of fire.

324. Perform the same experiment with filings of antimony, and the result is still more brilliant.

The best method of performing these experiments is to have a tall jar. Let three or four drops of bromine fall to the bottom of the jar, and pour a spoonful of boiling water upon the bromine, or better touch it with the point of a red hot wire.

325. Place a minute piece of potassium on to a drop of bromine, and the two substances will unite with explosive violence. This, for the sake of safety, should be performed only out of doors, and the potassium dropped from the end of a long stick. *Note.* As bromine, both as a liquid and vapor, corrodes the skin, and turns it yellow, care must be taken that the hands are not exposed to contact with it.

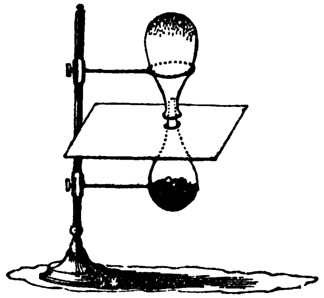
The compounds of bromine are called *Bromides*, which see.

IODINE,

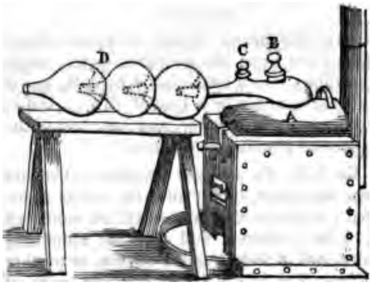
Is an element found in the ashes of sea weeds and of sponge. In general characters it is similar to chlorine. It is solid, of a dark blueish grey color and metallic lustre, has a pungent odour, an acrid taste, stains the skin of a deep brownish yellow color, and in some degree destroys the vegetable colors. It is in a very slight degree soluble in water, unless the water be impregnated with a salt, when it dissolves a larger quantity. It is soluble also in ether, alcohol, and in solutions of its own salts, the iodates.

Ex. 326. *To procure iodine.*—Burn sea weeds to ashes; dissolve the soluble parts in water, evaporate this, and separate the salt. The mother liquor now left is to have sulphuric acid in excess mixed with it, and this mixture is heated in a retort, iodine rises in *violet-colored* vapors, and condenses in a solid form in the receiver. An addition of the binoxyde of manganese to the mixture favors the production of iodine.

327. *Second method.*—Heat the mother liquor to a temperature of 230°; pour it into a stone-ware basin, and add ⅛ part of sulphuric acid; this deposits every thing from the liquor but hydriodic acid. Filter this through paper, away from the sediment. Now mix 1 pound of the binoxyde of manganese with every 12 ounces, apothecaries measure, of the filtered liquid in a glass retort, which must not be more than half full, and apply heat. The iodine will pass over, and is to be collected in a cooled receiver. Dr. Ure recommends a glass flask to be used, and the iodine, which is deposited in small crystals, to be condensed in a large globe or receiver placed above it, in the manner represented in the following figure, interposing a disk of wood, or tin plate, with a hole in the centre, between the flask and the receiver, that the latter may not be heated too much by the hot air ascending from the lamp or other source of heat. From 80 to 100 grains of iodine are obtained from the above quantity of liquor.



328. The following apparatus is recommended in Graham's "Chemistry" for the manufacture of iodine on a large scale. "The filtered liquor of the last experiment is placed in the leaden retort A, which is of a cylindrical form and supported in a sand bath, heated by a small fire below. The retort has a large opening at the top, to which is fitted a head, having two openings B and C, each closed by a leaden stopper. A series of bottles, each with two openings, connected together as represented by the figure, are used as condensers. The prepared ley, being heated to about 140° in the retort, the manganese is introduced, and the head is then luted to the opening of the retort. Iodine immediately begins to come over, and passes into the condensers. Additional quantities of sulphuric acid, or manganese, are introduced occasionally at B, if required."



Sublimation of iodine.—See *Ex.* 170.

329. *Iodine vapor.*—Boil a little iodine, with 5 or 6 ounces of water, in a Florence flask. The vapor of iodine rises along with the vapor of the water, and presents a very singular appearance.

330. Inclose a grain of iodine in a long glass tube, hermetically sealed. Hold the part which contains the iodine over a spirit lamp, and it will be converted into a violet-colored gas, which fills the tube, disappearing and becoming solidified as the tube cools.

331. Cut three or four very thin slices of phosphorus, place them on a tin cup, when they have been well dried, and throw a little iodine upon them. The substances will combine, a heat be extricated, and if allowed contact with air, or with oxygen, the phosphorus will be inflamed.

332. Perform the last experiment in an exhausted receiver; heat will be extricated as in the former instance, but no light, because there is no oxygen present to support combustion.

333. *Does not support combustion, or life.*—Into a jar of the vapor of iodine immerse a lighted taper; it will be immediately extinguished. An animal submitted to the same test is killed, but not so quickly as with some other gases.

334. The vapor of iodine is seen to great advantage when a scruple or two are thrown suddenly upon a hot plate, or brick.

335. *Lugol's solution of iodine.*—Add to 1 ounce of water 20 grains of iodine; a very small portion will be dissolved. Add to this 30 grains of the iodide of potassium, and the whole is immediately held in solution. This solution is used in medicine, as is also the tincture, or alcoholic solution, for the cure of that horrible disorder, the goitre.

The following remarkable history of the discovery and application of iodine is from Hoblyn's "Manual of Chemistry," p. 11.

He says :—" It will be found that there is no science so intimately connected with the arts of life, with the very life itself of man, as chemistry. The practical application of chemical knowledge in the discovery of *new* substances is full of interest. One instance may here suffice. In the manufacture of soap, the vessel employed is found to be corroded; the scientific chemist analyses the corroding matter, and the result is the discovery of one of the most singular and important chemical elements, *iodine*. Curiosity is excited; the origin of the new substance is traced to the sea plants, from whose ashes the principal ingredient of soap is obtained, and ultimately to the sea-water itself. It is thence hunted through nature, discovered in salt mines and springs, and pursued into all bodies which have a marine origin; among the rest, into sponge. A medical practitioner then calls to mind a reputed remedy for the cure of one of the most grievous and unsightly disorders to which the human species is subject—the *goitre*, which infests the inhabitants of mountainous districts to an extent that, in this favored land, we have happily no experience of, and which was said to have been originally cured by the ashes of burnt sponge. Led by this indication, he tries the effect of iodine on that complaint, and the result establishes the extraordinary fact, that this singular substance, taken as a medicine, acts with the utmost promptitude and energy on *goitre*, dissipating the largest and most inveterate in a short time, and acting as a specific, or natural antagonist, against that odious deformity. The history of chemistry is full of facts of equal, or greater interest and importance."

CARBON.

This element is found in numerous states; in its purest condition it is the diamond. In other forms it constitutes graphite, vegetable and animal charcoal, coke, lamp black, and gas carbon. It enters very largely into the composition of organized substances, and united with oxygen forms therewith carbonic acid. It exists as a considerable portion of all chalks and limestones. In Prout's " Bridgewater Treatise" is this remark :— " In order to give some idea of the proportion in which carbon exists in different common substances, it may be observed, that a pound of charcoal is equal to, and is contained in rather more than 2 pounds of sugar, or flour, and 8 of potatoes, or limestone; so that a mountain of limestone contains the essential element of, at least, an equal bulk of potatoes, and of a forest which would amply cover many such mountains." Carbon unites with oxygen, sulphur, phosphorus, some of the metals, &c.

Ex. 336. *To procure charcoal.*—Charcoal is usually made by piling together into a compact conical heap, the branches of oak, beech, birch, willow, and other trees, covering them over with green turf, leaving holes for the admission of fire; when well lighted, these holes are also covered, and the wood burns as long as it contains gaseous particles, or as long as its own oxygen will support the combustion. The fire then subsides; the charcoal cools; and when quite cold is removed for use.

337. *Another method.*—Fill a large gas retort with billets of wood; let it have a pipe to convey away any gas which arises. Place the retort over a furnace, and kindle a fire beneath the retort. When red hot, gases and liquid products will pass out of the attached pipe, and the wood become converted into a very pure charcoal; and which is preferred for the manufacture of gunpowder. For this purpose the willow tree is esteemed.

338. *To make it on a small scale.*—Cut some pieces of wood of a convenient shape, and place them in a crucible, cover them over with fine sand, and place the crucible in the fire; keep it at a red heat for an hour, let the crucible get quite cold, and the wood will be found converted into charcoal. In this manner, box-wood charcoal is made for galvanic deflagration, and also crayons for artists. These last should be of willow-wood, the bark being previously taken off. For chemical use, it should be kept in stoppered bottles, as it rapidly absorbs air and moisture.

339. *To make it from lamp black.*—Lamp black is charcoal in a state of fine powder, but mostly contaminated with tar or oil. To purify it; place the lamp black in a crucible, cover it with sand, and heat it in the same manner as the wood in the last experiment.

340. *To make it of animal materials.*—Place horns, hoofs, bones, or any other animal matter into a crucible, and proceed as before; the result is animal charcoal or *ivory black*.

341. *To make it from sugar.*—To a phial half full of a syrup of sugar, add a little strong sulphuric acid. The thick colorless liquid will become thin, and turn immediately of a black color, and after a few minutes, deposit a large proportional quantity of a black powder,—this is nearly pure charcoal. The reason of the experiment is this :—Sugar is composed of oxygen, hydrogen and carbon, the two former are in the same proportions as they exist in water, therefore sugar may be considered as a peculiar compound of charcoal and water; the sulphuric acid has a strong affinity for water, consequently, it seizes the water of the

sugar, and suffers the charcoal to fall. Why it decomposes sugar, rather than unites with the watery part of the syrup is not so easily explained.

342. This experiment may be varied by suffering a drop of sulphuric acid to fall upon a lump of sugar; the sugar will gradually grow darker, until it becomes of a full black, emitting, even from the contact of the acid, a strong odour of wood smoke.

343. *Variation as a sympathetic ink.*—Write upon ordinary paper with sulphuric acid, using a quill pen; the writing will for a time be invisible. It may be seen of a full black color, by holding the writing to the fire. The heat assisting the action of the acid upon the paper, the latter becomes decomposed; for as it consists of similar constituent principles as sugar, the acid unites with its oxygen and hydrogen, and deposits the carbon.

344. *Charcoal from starch, &c.*—Dip a piece of starch in sulphuric acid; place it afterwards on the hob of a stove, or hold it close to the flame of a candle, and it will turn of a jet black, not from scorching, but chemical decomposition.

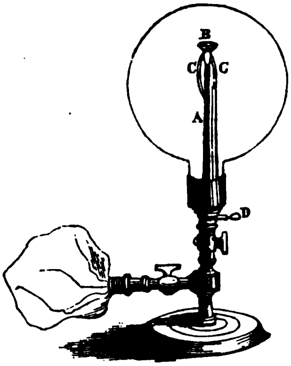
345. Drop some sulphuric acid upon sawdust, and it will instantly become of a jet black; after a time scarcely any thing but pure charcoal remains. May not this account for the black color of coals? the sulphates decomposing, by time, vegetable masses that they come in contact with in the earth.

346. *To procure charcoal from the vapor of turpentine, &c.*—Pass the vapor of alcohol or turpentine through a red hot tube: it will be decomposed, and a considerable quantity of carbon be deposited in the state of a black powder.

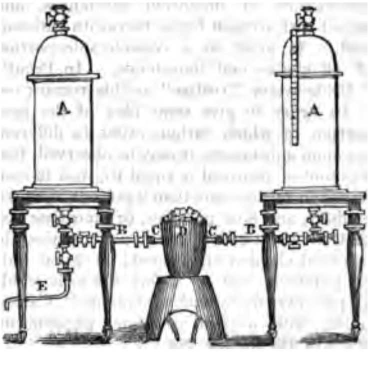
Combustion in oxygen. See *Ex.* 222.

Combustion of the diamond. See *Ex.* 223.

347. *Apparatus for.*—The following is the form of apparatus which may be conveniently employed for exhibiting the results of the combustion of the diamond. It consists of a glass globe, of the capacity of about 140 cubical inches, furnished with a cap having a large aperture. The stop cock, which screws into the cap, has a jet A, rising from it, nearly into the centre of the globe; this is destined to convey a small stream of hydrogen. Two wires C C, terminate at a very little distance from each other, just above this jet, and are intended to inflame the stream of hydrogen by electrical sparks; one of them commences from the side of the jet, the other is inclosed and insulated nearly in its whole length in a glass tube. This wire terminates at D. The stand and bladder will be understood. The diamond is placed in the platinum cup B. The stand being taken off, the air is exhausted from it by an air-pump, and then filled by the bladder with pure oxygen. This first bladder is to be taken away, and a second bladder, filled with hydrogen, substituted. A small stream of this is let on, and being inflamed by a spark taken at D, the capsule and diamonds become white hot, and enter into combustion, when the hydrogen may be turned off.



348. The following method of illustrating the products of the combustion of the diamond was employed by Messrs. Allen and Pepys. A A are two mercurial gasometers, one of which is filled with pure oxygen. The brass tubes B B, properly supplied with stop cocks, issue from the gasometers, and are connected with the platinum tube C C, which passes through the small furnace D. E is a pipe to draw off the gas when the experiment is concluded. A given weight of diamond is introduced into the centre of the platinum wire, which is then heated to bright redness; and the gas passed over it, backwards and forwards, by alternately compressing the gasometers. Carbonic acid is soon formed, and it will be found that the increase of weight sustained by the oxygen is equivalent to that lost by the diamond; that the oxygen



undergoes no change of bulk; and that the results are in all respects similar to those obtained by a similar combustion of pure charcoal.

349. *Absorption by charcoal.*—Take a piece of newly-prepared charcoal, and immediately it is removed from the crucible weigh it accurately; after being weighed lay it aside for a few days; if it be now weighed a second time, it will be found much heavier, having in the interim absorbed air and water.

350. *Absorption of ammoniacal gas.*—Fill a jar with the gas, or fumes of ammonia, and place in it a piece of fresh charcoal; after 24 hours the whole of the ammonia will be absorbed—no odour remaining. Charcoal thus absorbs 90 its bulk of ammoniacal gas.

351. Repeat the experiment with the following gases, when it will be seen that it absorbs them in various proportions, as under:—

Muriatic acid	95
Sulphurous acid	65
Nitrous oxyde	40
Carbonic acid	9·42
Oxygen	9·25
Nitrogen	7·5
Carburetted hydrogen ..	5
Hydrogen	1·75

352. Shake some fresh and well-burnt charcoal in a phial with water contaminated with sulphuretted hydrogen; it entirely deprives it ofthat gas, so that when filtered, it is perfectly inodorous. The more porous the charcoal, the better for the purposes of absorption.

353. *To recover tainted meat, water, &c.*—Should meat, water, &c., become tainted or musty, place in contact with it some powdered animal charcoal; the meat, &c. will after some time lose its ill savor, and become perfectly sweet. This is the reason why charcoal makes so valuable a tooth powder; for this purpose animal charcoal, that is, ivory black must be used.

354. *Cleansing of clothing.*—Clothes and other articles often contract disagreeable scents, arising from damp sea voyages, disease, certain medicines taken internally or externally, peculiar occupations, manufactures, &c. These may be all rendered perfectly sweet, by wrapping up in them for a few hours some pieces of animal charcoal.

355. *Absorption of lime.*—Boil some animal charcoal with lime water; the water will lose the whole of its lime, which the charcoal will take up. This effect M. Payen says, is not possessed by lamp black or vegetable charcoal.

356. *Discoloring properties.*—Boil some brown sugar in water, and set half of it aside to cool, and to the other half, add powdered animal charcoal; boil this a second time, the charcoal will absorb the color of the sugar. This is the reason why sugar bakers use so much animal charcoal.

357. The same effect takes place by filtering the colored solution through a bed of charcoal, 2 feet in thickness, and placed in a tub for the purpose. Charcoal of charred blood is the most efficacious. Wood charcoal has very little discoloring effect.

358. Filter a solution of the sulphate of indigo through a depth of 2 feet of animal charcoal, it will pass through entirely divested of color.

359. Boil common vinegar with charcoal powder, and it will become perfectly colorless.

360. *Effect on nitric acid.*—"Expose some well-pounded charcoal to a red heat in a covered crucible, remove it, and then drop some nitric acid upon it from a dropping tube with a long stem. The charcoal takes oxygen from the acid, and a shower of sparks is thrown out. Charcoal in a minute state of division decomposes this acid at a much lower temperature."—*Reid's Chemistry.*

361. *Decomposition of hard coke.*—Hard coke, anthracite, and some other carbonaceous substances will not burn alone; if it be required to prove them to be carbon, they must be deflagrated with nitre, thus:—Take 2 or 3 grains of coke that will not burn in an ordinary fire, and which is usually known by being of a leaden color, and of a vitreous appearance; reduce them to a fine powder, mix them with thrice their weight of nitre, and heat the mixture in a green glass tube, held in the flame of a lamp. The mixture should not occupy more than a quarter, or at most half of an inch in depth of the tube. The carbon receives oxygen from the nitre, and produces carbonic acid, which combines with the potass and forms the carbonate of potass.

362. *Deflagration of sulphuric acid by red hot charcoal.*—Tie a spoon to the end of a long stick, pour into it a little sulphuric acid, and holding the stick at the farther end, pour the acid upon some glowing charcoal; immediate deflagration will take place from the rapid decomposition of the acid; part of which will be thrown out, by the quick disengagement of carbonic acid gas. When the action has subsided, sulphur will be found precipitated on the charcoal. Here the charcoal, in a red hot state, has more affinity for oxygen than sulphur has in the state of sulphuric acid; the consequences are, the formation of carbonic acid, and the precipitation of sulphur.

363. *Deflagration of charcoal with nitre.*—If half an ounce of nitrate of potass (saltpetre,) be made hot in a crucible, and

a quarter of an ounce of powdered charcoal thrown into it in this state, a most beautiful explosion and combustion will take place. The new products are carbonic acid gas, carbonate of potass, and nitrogen gas; the second is stationary, while the first and third fly off. The decomposition is obvious. The charcoal combines with the oxygen of the nitric acid, forming carbonic acid, which seizes on the potass, now free, while the nitrogen, combining with caloric, forms gas.

364. *Second method.*—Pulverize a quarter of an ounce of the nitrate of potass, and half that quantity of charcoal, mix them together, and put them on a fire shovel in the chimney corner, or on the side of the grate. Touch the compound with a red hot iron, very brilliant combustion will be the consequence. The nitrate will of course be decomposed, and the same results take place as in the former instance. This experiment shows the value and effect of charcoal in gunpowder, fire-works, &c.

Deflagration with nitrate of silver and with the chlorate of potass, *Ex.* 44 and 45.

365. *Charcoal and chlorate of silver.*—Throw, from the point of a knife, 3 or 4 grains of chlorate of silver on red hot charcoal, deflagration will be the consequence, and the silver will be reduced to a metallic state on the charcoal.

366. *Charcoal and iodate of potass.*—If 6 grains of charcoal in powder be gently mixed with 6 grains of iodate of potass, and laid (folded in a small piece of paper), on an anvil, a smart blow from a hammer will cause a loud detonation.

367. Vary the last experiment by throwing the iodate of potass reduced to a powder on to red hot charcoal, the decomposition will be more rapid and beautiful. Here the iodate is decomposed, the charcoal combines with the oxygen of the potass, and also of the iodic acid, forming carbonic acid gas; while the salt is changed into iodide of potassium.

Hot charcoal has so great an affinity for oxygen, that it separates it from most of the metallic oxydes, and of course reduces them to a metallic state, as from the following examples:—

368. *Reduction of the oxyde of lead.*—Mix 4 ounces of red lead with 1 ounce of charcoal powder, put the mixture into a crucible, stir them well together, so that the color of the mixture may be a dirty brown. Put the crucible into a clear fire, and give it a red heat for a quarter of an hour; when sufficiently heated, pour out the contents of the crucible, and metallic lead will run from under the powder at the top.

369. *To obtain lead from glass.*—Break a bit of flint glass into very small pieces, and put them into a crucible with powdered charcoal. Place this in a hot fire, and when the glass has been fused about ten minutes, take the crucible from the fire and pour out the contents, metallic lead will be found amongst them. This lead existed previously in the glass in a combined and transparent state, on account of the action of the silica and potass on its oxyde, but it is now reduced in an opaque, uncombined metallic state, owing to the abstraction by the charcoal of the oxygen with which it had been previously combined.

SULPHUR,

Is an element of a yellow color, without smell, (unless rubbed,) or taste, and perfectly insoluble in water. It melts readily at the heat of 216°, only four degrees above that of boiling water; at 300° it becomes thick and brown; at a heat of 600° it sublimes, when it is called *flowers of brimstone.* It crystallizes as it cools in needle-shaped crystals. It is found abundantly in volcanic countries in an uncombined state, also almost every where combined with metals. It may be dissolved by being boiled in oil of turpentine, and partially in the volatile and fat oils, in alcohol and ether. It combines with oxygen, chlorine, iodine, carbon, hydrogen, and most of the metals, forming with oxygen various acids, with chlorine, iodine, and the metals sulphurets.

Various properties of sulphur. See *Ex.* 1, 237, 273.

Combustion in oxygen. See *Ex.* 220.

Sublimation of sulphur. See *Ex.* 164.

Crystallization of. See *Ex.* 196.

370. *Sulphur moulds of coins, &c.*—Prepare the coin, or other body of which the mould is to be made, by slightly oiling the surface, or if the body be made of plaster of Paris, the back of it is to touch the surface of water in a saucer or other convenient vessel, until the water just appears upon the surface, which will be known by its becoming more glossy. Then having a sufficiently-long strip of thick paper, from ½ an inch to an inch and a ½ in width; fold this round the coin—hold the paper between the thumb and fingers of the left hand, or if the medal should be large, or if a number are to be done at once, fasten the end of the paper with paste. Then melt by a very slow and gentle heat a little roll brimstone; when in a melted state, and while quite liquid, pour it steadily upon the coin. In a few minutes it will become crystallized into a semi-transparent mass, which may be removed from the coin or plaster cast, and will be found to be a fine and very exact counterpart of the original; and having plaster of Paris afterwards poured into it will yield a very perfect impression.

Rubbed over afterwards with black-lead in powder, sulphur forms excellent moulds for electro-type.

Note.—By this method moulds of the very numerous and beautiful ancient and modern gems, made by the Italians, are formed. A number may be made at once, placing them side by side on a table, and pouring sulphur into each. The following remarks may assist the young experimentalist:—a silver coin must never be used, because sulphur immediately combines with the metal, and forms a sulphuret of silver upon the surface, which is a black powder. Even silver money carried in the pocket becomes so much tarnished that it is scarcely passable. If the sulphur while on the fire should become inflamed, cover it over with a piece of wood, small plate, or any thing else convenient, but do not put in water to it. Should it become thick you must wait a *time*, and let it cool, that it may return to its perfect fluidity. Sulphur which has been submitted to too much heat turns brown, and becomes tougher than before, but does not take quite so fine an impression. It is advisable then to pour a little fresh sulphur, first upon the coin, and then to increase the thickness by filling up with the darker-colored sulphur. When the moulds required are large, the expense of sulphur may be diminished by pouring upon it merely a coat of this material, just to cover the surface. Then sprinkle over this coat a few small pieces of coke or cinder, before the sulphur congeals, or if it should have congealed fasten these pieces down by pouring a little more sulphur around them. When fixed, pour some common plaster of Paris upon the coke to the required thickness, the coke will unite the sulphur and plaster, and render the whole sufficiently solid for use; though all articles cast in sulphur remain very brittle for some time after casting, nor must they at any time be subjected to sudden and violent changes of temperature.

371. *To make red sulphur gems.*—Make a mould of the required subject in plaster of Paris; melt some roll brimstone over a gentle fire—when just melted, put in a little *English* vermilion; stir them together, and pour the mixture immediately into the moulds in the manner of the last experiment; it will congeal, and give a very sharp impression, which has the peculiar advantage of not being injured by the heat of the sun. By this method are made the red casts seen in engraver's windows, and which resemble sealing wax. They may be when made surrounded with fillagree paper, and placed upon show boards, or in cabinets. The great difficulty of the above process is the preserving the gems of a fine red color. This is only to be done by keeping the sulphur at as low a degree of heat as possible, otherwise the vermilion, which is a bisulphuret of mercury, becomes in some degree changed into the protosulphuret, or Ethiops mineral, which is black. The surest way to preserve a fine color is to procure a common glue pot, put the sulphur to be melted in the inner vessel, and fill the outer vessel with brine. The boiling of the brine will communicate heat enough to melt the sulphur, but not to occasion a rapid decomposition. Notwithstanding this precaution, the sulphur should not remain long in a melted state, but be used as soon as possible.

372. *To make sulphur coins.*—Prepare first the requisite moulds of both sides of the coin, by pouring plaster of Paris on each side alternately. Make a line, or other mark, on each mould, to show the position that they are afterwards to be placed in, that the heads and devices may be in such a position relative to each other, as they are in the original coin. Then melt some sulphur, (that is best which has been melted two or three times before, so that it has acquired a light brown color.) When ready to pour, hold the two moulds at the proper distance from each other, according to the thickness of the coin, and with the marks of both in a line with each other, and wind round the edge of the moulds a strip of card, in such a manner, that the card shall go very nearly round them; a small vacuity only being left at the top. This being prepared, hold the card between the fingers and thumb, then pour in the sulphur, and as it *s*hrinks, pour in more, until the space between the moulds is full. It will immediately congeal, and when removed it will be found to have taken a fine impression from the moulds, and to have all the sharpness of the original coin. When taken out, it may be trimmed with a knife around the edges, for sulphur has the property of remaining soft for some considerable time after melting. To give the artificial coins clearness, and an appearance of antiquity, they must be rubbed all over with black-lead, and then the black-lead removed from the more prominent parts with a soft damp rag. A fine metallic appearance is given to medals by varnishing over the black-lead surface, with a weak solution of dragon's blood in spirits of wine, instead of partially rubbing the black-lead off. The moulds must of course be damped previously to using, as recommended in *Ex.*370.

373. *To prepare milk of sulphur.*—(Precipitated sulphur of the Pharmacopœias). To a solution of the sulphuret of potass, add sulphuric acid. This will seize upon the potass, and liberate the sulphur, which will fall down to the bottom of the vessel in the state of a whitish yellow powder, which is called the milk or cream of sulphur.

374. *To obtain perfectly pure sulphur.*—Boil some flowers of sulphur, which are common brimstone sublimed, in 10 times their weight of spirits of turpentine. This solution will remain clear at 180° of heat, but in cooling will deposit needle-shaped crystals, which may be washed in cold alcohol, or warm water, and put by for curiosity or use. The common flowers of sulphur are sufficiently pure for ordinary purposes. The purity of sulphur may be judged of by heating it on a piece of platinum foil; if pure it will, upon heat being applied, burn away without leaving any residue.

Sulphur explodes with the chlorates, iodates, and nitrates. See *Ex.* 41, 42, 46, and 49.

Sulphur unites with mercury, forming Ethiops mineral. See *Ex.* 70.

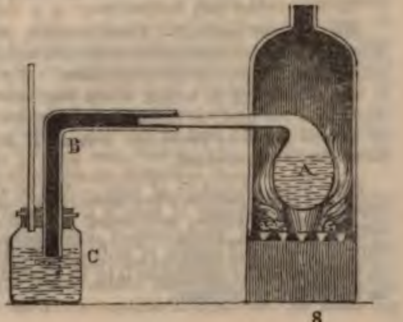
375. *Bleaching by sulphur.*—Straw bonnets, discolored paper, and numerous other articles, are bleached by the fumes of sulphur. The articles to be bleached are made damp, and then placed in a box or close room; 2 or 3 ounces of roll sulphur are melted in a pipkin, and kept on the fire till they inflame spontaneously. Then the pipkin is placed, with the sulphur in it still burning, among the goods to be bleached, and the box or room closed as tightly as possible. The sulphur in burning unites with oxygen, and forms sulphurous acid, which flies off in vapor, and is absorbed by the moisture upon the surrounding objects, which thereby become bleached.

376. *Deadly character of the fumes.*—It is well known that the fumes of burning sulphur are stifling, and occasion most violent coughing; it is necessary to fly at all times from their influence, or death would be the consequence. For this reason burning sulphur is used to destroy bees in the hive previous to taking the honey. A bundle of matches lighted will effectually destroy all the bees of a hive, sometimes 20,000 in number. Insects to be preserved for the cabinet are mostly killed by the fumes of sulphur, though the fumes of prussic acid are preferable, because sulphur sometimes injures their colors.

PHOSPHORUS.

This element, which obtained its name from the well-known property of shining in the dark, is when pure, tasteless, of a garlic-like odour, colorless or of a pale pinkish yellow, semi-transparent, flexible at common temperatures. It freezes at 32° or becomes crystalline. Fuses at 105°, when exposed to the air; takes fire at 165° or less if partially oxydated; boils at 550°, (air being excluded), and distils over in the state of a colorless vapor.

Ex. 377. *Preparation of phosphorus from bones.*—When bones are burnt to whiteness in an open fire, the animal matter they contained is dissipated, and nothing remains but a solid mass of a fine white color, consisting almost entirely of phosphate of lime, a compound of phosphoric acid and lime. It is from this that phosphorus is usually prepared. A superphosphate of lime is formed in the first place, by mixing the phosphate in fine powder, with ¾ its weight of sulphuric acid, previously diluted with an equal weight of water. Stir this mixture till of a uniform consistence. The sulphuric acid combines with the greater portion of the lime, and the phosphoric acid set at liberty attaches itself to a portion of the phosphate which is not decomposed, forming superphosphate of lime. After the mixture has been kept for a day or two, stirring it frequently, and adding more water to keep it quite fluid, it is put into a linen bag. The superphosphate of lime, which is dissolved by the water, filters into a receiver, placed below, while the sulphate of lime remains. More water is poured upon the mass as long as the liquor which passes through is sensibly acid; and the filtered solutions are then evaporated, till they assume a syrupy consistence, when they are to be mixed with as much powdered charcoal as may render them solid. On drying the mixture, and exposing it in an earthen retort to a strong heat in a furnace, phosphorus is disengaged, and as it is easily volatilized, it may be collected by connecting the beak of the retort with a tin tube, which is made to dip into water. This tube must always be kept warm, lest the phosphorus should congeal, and not drop into the water as required. A very minute account of the manufacture of phosphorus is given in the "Magazine of Science," Vol. II, p. 162. In the annexed figure, partly taken from Metscherlich's arrangement of apparatus for this purpose, A is the body of the earthen retort. B the wide tube leading the gas and phosphorus into the receiver C, from which the gas escapes by the long small tube.



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378. *Phosphorus from phosphoric acid.*—If a small quantity only be wanted for illustration it may be made of other substances, as under:—Put phosphoric acid, mixed with half its weight of charcoal, into a green glass tube, sealed at one end, about a foot in length and half an inch in diameter. Coat that part of the outside of the tube, which is to be heated, with a mixture of two parts of clay and one of sand, previously mixed with cut thread or flax, and bind the whole on with iron wire. A retort coated in the same way may be used with equal convenience. It is to be placed in a furnace, as shown below, and the beak of it made to dip under the surface of warm water in a bason. When the retort is brought to a red heat, phosphorus will distil over, and fall into the water.

379. *Phosphorus from ivory black.*—Wöhler recommends to calcine ivory black, which is a mixture of phosphate of lime and charcoal, with fine quartz sand, and a little more ordinary charcoal, in cylinders of fire clay, at a very high temperature; each cylinder has a bent copper tube attached to it, one branch of which descends into a vessel containing water.

380. *Phosphorus from urine.*—Evaporate the urine to dryness; then expose it to a high temperature in the manner of the last experiment. Phosphorus will at length pass over, and may be collected in warm water. The carbon of the animal matter decomposing the phosphoric acid which it contains.

381. *Second method.*—Add a solution of nitrate of lead, or nitrate of mercury, to urine; collect, wash, and dry the precipitate. Mix it with one-fourth its weight of charcoal, and distil by a red heat, as before. The nitrate of mercury is to be preferred, because it is more easily decomposed.

382. *From phosphate of soda.*—Add to a solution of phosphate of soda a solution of acetate of lead; phosphate of lead being thrown down, and acetate of soda remaining in solution. The precipitate is to be treated as in the last experiment.

383. *To purify phosphorus.*—That obtained by the foregoing experiments is of a reddish color and impure. To purify it, tie it up in a piece of wash-leather, soak it in hot water, and squeeze the bag with a wooden squeezer in the manner that lemons are squeezed, letting the phosphorus which oozes out through the pores of the leather fall into the water. It will now be pure and colorless.

384. *To cast phosphorus in sticks.*—Procure a slightly tapering glass tube, close one end with a cork, and warm by immersion in hot water. Dissolve the phosphorus in hot water, contained in a basin with a spout to it; when melted, pour the liquid phosphorus, water and all, into the tube, holding it over a vessel to catch what water or phosphorus may be spilled. When congealed by gradual cooling, the stick of phosphorus will usually fall out upon the cork being removed, or if not it may be thrust out with an iron wire.

385. *To handle phosphorus.*—This must always be done under the surface of cold water, or if pieces are handled in the air, great care must be taken that they do not arrive at a heat above 100°, and particularly that no particle adheres to the hands, or gets beneath the nails. As the exact heat at which phosphorus inflames depends upon various causes, a slight degree of friction, like that of writing with it, as in *Ex.* 387, warming the hands at the fire, contact with various bodies, partial oxydation, &c., will very often occasion combustion, and if the hands be not defended with gloves, and the phosphorus not kept cool, the most dreadful burns may be occasioned. It must be kept in bottles filled with water.

386. *Slow combustion of.*—Cut several thin slices of phosphorus, dry them on bibulous paper, moving them from place to place upon it, but never touching them with the fingers, and heap them loosely together in a little tow or cotton; a slow combustion goes on, which often increases till the phosphorus inflames, but the result is affected so much by the currents in the air, and upon the manner in which the small particles of phosphorus touch each other, that it is impossible to predict the result.

387. *Phosphoric writing.*—Insert a small piece of phosphorus into the end of a quill. Holding the quill in the hand write upon a wall with the phosphorus; the characters will in the dark appear luminous. A bason of cold water must be at hand to quench the flame, should the phosphorus become inflamed, which it is very likely to do in consequence of the heat arising from the friction.

388. *Luminous steam.*—Boil in a Florence flask a little water, into which has been dropped two or three small pieces of phos-

phorus. Part of it rises in vapor along with the steam, and renders it luminous when it comes in contact with the air. This phosphorescent steam is not capable of setting fire to inflammable substances. Upon cooling, the water will not be found to have imbibed any of the phosphorus.

389.—*Luminosity of phosphorus destroyed by various vapors.*—Heat some sulphuric ether in a spoon, and as the luminous steam of the last experiment issues from the mouth of the flask, suffer the vapor of the ether to mix with it—luminosity will be immediately destroyed. This will also be the case when it meets with the vapor of the oil of turpentine, or the vapor of naphthaline.

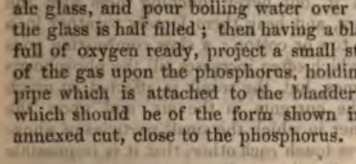
390. While luminous phosphoric characters are shining on a wall, suffer the vapor of either of the above liquids, or a very small proportion of olefiant gas, to mix with the white fumes arising from the letters, and the phosphorescence will at once cease; also the vapor and gas may be in very minute quantity.

391. *Phosphorized ether.*—Boil a grain of phosphorus in an ounce of sulphuric ether, contained in a phial; enough will be dissolved to render the ether luminous when exposed to the air. Cork the phial, and the phosphorescent appearance will cease; to be renewed each time the phial is uncorked.

Phosphoric oil. See *Ex.* 80, and 81.

392. *Phosphorized alcohol.*—Repeat *Ex.* 391, with alcohol, or with spirits of turpentine, instead of with sulphuric ether; and a sufficient quantity of phosphorus will be dissolved to render the fumes above the liquid luminous, whenever the cork is withdrawn from the containing phial.

393. *To inflame phosphorus under water.*—Put a few grains of phosphorus into an ale glass, and pour boiling water over it till the glass is half filled; then having a bladder full of oxygen ready, project a small stream of the gas upon the phosphorus, holding the pipe which is attached to the bladder, and which should be of the form shown in the annexed cut, close to the phosphorus.



394. *Change from combustion in the air.*—When phosphorus is inflamed in atmospheric air, a large quantity of white fumes is formed, which may be collected by inclosing the phosphorus in a glass jar. The fumes will then condense into masses like flakes of snow, they are metaphosphoric acid.

Combustion in oxygen. See *Ex.* 219.

395. Inclose a particle of phosphorus in a phial of oxygen, put the stopper into the phial, and suffer it to remain undisturbed for some hours; upon opening the phial, no luminous fumes will arise, unless the oxygen be heated to 80°. Now mix with the oxygen in the phial a small quantity of either hydrogen, nitrogen, or carbonic acid, and set it aside as before; these substances dissolve a small portion of the phosphorus, and the gas becomes phosphorescent when the stopper is removed; or in other words, they allow of the slow combustion of the phosphorus whereas oxygen alone does not, unless at more than 80° of temperature.

396. *Change of color in.*—Suffer melted phosphorus to drop suddenly into very cold water, or on to the surface of ice, and it will instantly change to a black color.

397. *Decomposed by light.*—Phosphorus exposed to light gradually becomes covered with a film of a red powdery substance, which impairs its properties; to prevent this, it should be kept in opaque bottles.

398. *To obtain crystals of.*—Make a saturated solution of phosphorus in hot naphtha. As this solution cools, crystals of a regular dodecahedral form will be obtained. They may be kept in the solution itself.

399. *Second method.*—Fuse phosphorus with about half its weight of sulphur: suffer this mixture to cool gradually, and a part of the phosphorus separates in the state of crystals. The fusion of the two substances must be conducted without contact with the air, or combustion ensues; and this so violent as not to be unattended with danger.

400. *Combustion by friction.*—Take a minute piece of phosphorus on the end of a match; rub it upon the surface of a cork, or piece of wood. The friction will inflame the phosphorus.

401. Lay a thin slice of phosphorus on woollen, lint, feathers, dry paper, or other bad conductor of heat; it will most frequently become inflamed by the heat occasioned by its own combustion, particularly with the least friction. It is also much more inflammable when dusted over with powdered charcoal, or flowers of sulphur.

402. *Lucifer or Congreve matches.*—These are a preparation of phosphorus, and are best made in the following manner:—The strips of wood are first dipped in melted sulphur; then afterwards the points of them touched with a composition made in the following

manner :—Place phosphorus, cut into small pieces, in a vessel, which may be closed accurately by a cover or stopper. Make an iron wire red hot, and stir up the phosphorus with it; it will be inflamed, and in some degree changed into an oxyde. The object of partially oxydating it, is to render it more inflammable. Withdraw the wire, and close the vessel, in order to stop the inflammation. Then dissolve in water four times as much gum arabic as there is phosphorus. Add the phosphorus previously prepared to the thick gum water, and heat it over a lamp, until the phosphorus is dissolved, or rather incorporated with the mucilage. Add a little coloring matter, and dip the sulphured ends of the matches in the mixture. When dry, they will become inflamed with a very little friction. Some manufacturers omit the slight oxydation of the phosphorus previous to its union with the gum water. Also it is common to stir in to the mixture, along with the coloring matter, a small quantity of the chlorate of potass. This promotes the combustion, and occasions the slight noise made at the ignition of the match.

403. *French receipt for ditto.*—Warm gum-water to a temperature of from 100 to 125°; to four parts of the mucilage, add one of phosphorus cut into small pieces, stir and mix them well; then add chlorate of potass, nitrate of potass, and gum benzoin, each in powder, and one-third in quantity that of the phosphorus. This altogether should form a thick paste, into which the matches are to be dipped.

404. *Inflammable match boxes.*—Take one part of dry cork raspings, one part of yellow wax, eight parts of petroleum, and four of phosphorus: incorporate them by fusion, pour a small quantity into a short phial, and when the mixture has concreted by cooling, it is capable of kindling a sulphur match dipped into it.

405. *Phosphorus and nitrochloride of gold.*—Immerse a white silk or satin ribbon in phosphoric ether, when the ether has evaporated, (which may be known by the smoking of the phosphorus on the ribbon,) immerse it in a wine glass containing a solution of nitrochloride of gold; the gold will be instantly reduced to the metallic state all over the silk.

406. *Phosphorus and silver.*—Immerse a stick of phosphorus into a phial containing a solution of nitrate of silver; after a very short time, the phosphorus will be covered with a bright film of metallic silver.

Combustion of in chlorine. *Ex.* 298.

Combination with iodine. *Ex.* 331.

Combination with bromine. *Ex.* 322.

Explodes with the chlorates, iodates, and nitrates. *Ex.* 39, 40, 47, 50.

Combination with potassium, sodium, and the chlorides, see these bodies.

BORON.

A substance discovered by Sir H. Davy in 1807. It is a powder of a deep olive color; infusible, inodorous, insipid, a non-conductor of electricity, not acted upon by air, water, alcohol, ether, or oils; but when heated nearly to redness, it takes fire, and burns with difficulty into boracic acid. Pure boron is of little known use, or interest; it may be obtained as follows :—

Ex. 407. *Preparation of boron.*—Place in a copper tube, closed at the lower end, a mixture of potassium and powdered boracic acid, using twice as much of the former substance as of the latter; and taking care that the boracic acid has been previously fused, and kept at a red heat for an hour or so, to drive off its water. Place the tube, thus partly filled, in a strong fire; when hot, the boracic acid will be decomposed—its oxygen uniting with the potassium forms potass, which may be washed away. The boron will remain in the filter.

408.—*Second method.*—According to Döbereiner, one part of charcoal or lamp black, intensely heated in a gun barrel with nine parts of borax, previously fused, and in fine powder, produces a dis-engagement of carbonic oxyde, and a blackish mass results, which after copious washings in boiling water, and once with muriatic acid, affords a greenish black powder, having the characters of boron mixed with a little charcoal.

409. *Third method.*—(Method of Berzelius.)—Instead of boracic acid, as in *Ex.* 407, use the dry fluoborate of potass; this is a salt obtained by adding a solution of the hydrofluate of potass to a solution of borate of potass, and heating the gelatinous precipitate that is thrown down, till it assumes the form of a white powder.

SELENIUM.

A singular substance obtained by Berzelius, in 1818, from certain specimens of sulphur. It has also been detected in several metallic ores. It is somewhat of the nature of sulphur, as the substances from which it is obtained are rare, the process of separating it very tedious and difficult, and its combinations of no known use, we pass over the subject of them, by referring those who desire to pursue the subject to "Ann. of Phil. xiv. 403," Ann. of Phil. N.S., viii, 104," and Brande's "Chemistry," p. 453.

CHAP. III.

METALLIC ELEMENTS OR METALS.

The metals constitute a large and important class of elements. They are forty-three in number, seven only of which, gold, silver, mercury, copper, iron, tin, and lead, were known to the ancients. Most of the others have been discovered within the last half century. All the metals are solid at ordinary temperatures except mercury, and may be fused at temperatures varying from 136° of Fahr., at which potassium fuses, to the intense heat of the oxy-hydrogen blowpipe, which is necessary to fuse platinum, and many of the more refractory metals. They all unite more or less with oxygen, forming sometimes oxydes; at others earths, alkalies, and acids. In appearance, color, degree of tenacity, and malleabillity, brittleness, hardness, elasticity, solubility in different menstrua, and capability of combination with each other; and with the non-metallic elements, the metals present great diversities. In the arts of life about thirteen or fourteen only are employed in their metallic state. Some of the others, however, though not thus used, in consequence of their rapid combination with oxygen, rendering it impossible to preserve them under ordinary circumstances with the properties of metals, are yet most valuable in the combined form which they assume, and are known as potass, soda, lime, clay, flint, magnesia, oxyde of manganese, strontian, &c. The rest are but little employed except by the chemist as tests. In this account of the metals, little will be said beyond their mere enumeration; the commoner metals are easily procurable, the rarer ones of little practical utility; or if valuable, it is rather in their combinations with the non-metallic elements, than as metallic substances themselves. The metals are best arranged according to the effect occasioned by their union with oxygen, and also the effect of heat upon them as follows:—

1. Potassium.
2. Sodium.
3. Lithium.
4. Calcium.
5. Barium.
6. Strontium.
7. Magnesium.
8. Manganese.
9. Iron.
10. Zinc.
11. Tin.
12. Cadmium.
13. Cobalt.
14. Nickel.
15. Copper.
16. Lead.
17. Antimony.
18. Bismuth.
19. Uranium.
20. Titanium.
21. Cerium.
22. Tellurium.
23 Arsenic,
24. Molybdenum.
25. Chromium.
26. Vanadium.
27. Tungsten.
28. Columbium.
29. Mercury.
30. Silver.
31. Gold.
32. Platinum.
33. Palladium.
34. Osmium.
35. Rhodium.
36. Iridium.
37. Glucinum.
38. Zirconium.
39. Yttrium.
40. Thorium.
41. Aluminium.
42. Silicium.
43. Lantanum

The metals, numbered 1, 2. and 3, united with oxygen form alkalies. The four next are the metallic bases of the alkaline earths. Nos. 38, 39, 40, 41, and 42, are the bases of the earths proper. The metals 22, 23, 24, 25, 26, 27 and 28, form acids when united with oxygen.

POTASSIUM

Is of a soft consistence, so that it may be cut by a knife; of metallic appearance and white color, fuses at 136° Fah., and absorbs oxygen so rapidly as to attract it from all surrounding bodies, and sometimes with considerable energy and rapidity. Thus it cannot be kept either exposed to air or under water, but only when immersed in a fluid which contains no oxygen, such as naphtha. Its union with oxygen forms the alkali potass.

Ex. 410. *To obtain potassium.*—Imbed a wide gun barrel, 18 inches long, in a lute of Stourbridge clay, and putting in a quantity of potass and iron filings, free from impurity; a smaller barrel, 8 inches long, is then to be inserted into the end of the larger one. This small one must be open at the top, and have a small aperture at the bottom for the admission of potassium in the state of vapor, as it is sublimed from the large barrel. The interstices between the tubes should be made air-tight, and the smaller one be plugged with a cork, through which runs a crooked glass tube, containing a globule of mercury, or still better a spoonful of oil. The mercury or oil will show by its motion that the apparatus is perfectly air-tight; an iron cap should cover the mouths of the barrels, but should have a perforation in the top for the transmission of the glass tube containing the mercury. The apparatus may now be plunged into a furnace or blacksmith's forge, and kept in a white heat for an hour; at the same time keeping the part of the barrels not in the fire perfectly cool, by wrapping the part not luted with linen, which should be kept constantly moist; the potassium at the close of the experiment will be found in the inner tube. The following is a figure of the apparatus :—

411. *Gay Lussac and Thenard's method.*—"A sound and perfectly clean gun barrel is bent as shown in the annexed sketch. It is then covered with an infusible lute between the letters O and F, and the interior of the luted part is filled with clean iron turnings. Pieces of fused potass are then loosely placed in the barrel between E and C. A A is a copper tube and small receiver, which are adapted to the extremity O, and to each other by grinding. This apparatus is next transferred to the furnace, as shown in the figure; X and T representing two glass tubes dipping into mercury. The furnace is supplied with air by a good double bellows, entering at B, and a small wire basket G is suspended below the space E C. The part of the barrel in the furnace is now raised to a white heat, and the escape of air by the tube X shows that all is tight. Some burning charcoal is then put in the end E of the cage G, which causes a portion of potass to liquefy, and fall into the lower part of the barrel upon the iron. Hydrogen gas instantly escapes by the tube X, and attention must now be had to keep the tube A A cool with wet cloths. When the evolution of gas ceases, fresh charcoal is placed under the potass, and so on till the whole has passed down; if too much potass is suffered to fall at once, the extrication of gas at X will be very violent, which should be avoided. If the space between A and O should become stopped with potassium, gas will issue from the tube T, which must always be kept under a greater pressure of mercury than the tube X, and the potassium must be cautiously fused by applying hot charcoal to the copper tube, when the gas will again appear at X, and cease at T. When the operation is concluded, the tubes X and T are removed, and corks quickly applied to the holes; and when the apparatus is cool, the barrel is carefully removed from the furnace, and a little naphtha suffered to run through it. The potassium is formed in globules in the tube and receiver A A, and considerable portions often lodge in O."—*Brande's Chemistry.*

412. *Brunner's method.*—The apparatus of Mr. Brunner is a globular iron bottle, covered with lute to preserve it from the effects of the fire. To the mouth of this is fitted by grinding a gun-barrel, bent into a form like the letter V reversed, or rather like a syphon; the end of this tube is dipped into a copper receiver partly filled with naphtha, and having a safety tube attached, and kept cold by water or ice. When in the fire, the whole of the bottle, and as much as possible of the tube, is exposed to the heat. In the globular bottle are placed 4 ounces of fused caustic potass, introduced in small portions alternately, with 6 ounces of clean iron turnings broken in a mortar, and 1 ounce of powdered charcoal, and this mixture is covered with 2 ounces more of iron turnings. This quantity will furnish from 100 to 150 grains of potassium.

Dr. Reid recommends an iron pot of the form of No. 1, in the following cut, about 12 inches deep, and 5 or 6 in diameter, the sides being of the thickness of at least $\frac{3}{8}$ of an inch. The top is turned a little outwards, and a lid of the same metal, and about the same thickness fitted accurately to it. The lid is secured in its place by an iron rod,

which is passed through two holes in the upper part of the sides of the pot.

The rest of the cut shows the two parts of a receiver recommended by Berzelius, which should be kept cold by ice. The upper part shown in the centre cut is about a foot high, 6 inches long, and 1½ broad, made of copper or sheet iron. It is open at the bottom and close at the top, divided in the middle by a partition A, with a small hole in it, and provided with three openings; one for connecting it with the gun-barrel, the opposite one, (usually stopped with a cork,) for the introduction of an iron rod to clear the barrel if stopped up, and another B for carrying off the gas which is liberated. The extremity of this tube is dipped into naphtha. The lower piece is half filled with naphtha, and made of such a size that the upper one shall fit accurately to it, and not slide up and down without some degree of friction. Using the above retort and receiver, the apparatus will assume the following character, the iron pot being presumed to be placed in a furnace.

Observe that in making potassium, a great quantity of an inflammable gas is liberated; should therefore the gun-barrel be obstructed, as it often is, the obstruction must be removed with an iron rod, or a dangerous explosion is likely to ensue. Potassium must always be kept covered with naphtha.

413. *Oxydizes in the air.*—Cut a piece of potassium with a knife; observe its metallic lustre, and how speedily it attracts oxygen from the air, a white crust, which is potass, gathering immediately upon its surface.

414. *Inflames on hot iron.*—Take a piece of potassium about a grain; that is, a piece about the size of a small peppercorn. Remove the naphtha adhering to it by blotting paper, and place it with a pair of pincers on a piece of red hot iron. It will immediately take fire, combining with the oxygen of the air and being converted into peroxyde of potassium.

415. *Burns brilliantly in oxygen.*—Put another piece in a deflagrating spoon, heat the spoon over the fire until it inflames the potassium; then immerse it into a jar of oxygen. The union of the metal with the gas will be very rapid, and the combustion greatly increased in brilliancy. The result is the same as in the last experiment, the peroyde of potassium which is an orange-colored matter. If a few drops of water be added to this, a part of its oxygen is disengaged with effervescence, and potass remains in solution.

416. *Inflames on the surface of water.*—Throw a grain of potassium into a little water in a bason or plate; supposing the naphtha removed from it previously, it will immediately decompose the water, and be decomposed itself. A part of it combines with a part of the oxygen of the decomposed water, forming potassa; while the other part, uniting with the hydrogen, forms the very inflammable gas, potassuretted hydrogen, which takes fire as it is disengaged, and is converted into potass and water. The potassium rolls along the surface of the water, till the whole of it is oxydated, burning with a rich rose-colored flame, and producing a very beautiful appearance. In performing this and similar experiments caution is requisite, as the fresh-formed caustic potass is sometimes thrown about with considerable force. The Author nearly lost an eye once in consequence of this dispersion of the potass.

417. *Inflames on the surface of ice.*—Put a small piece of potassium on the surface of ice, the same action takes place, and the same light is produced. The same caution as recommended in the last experiment is also necessary in this.

418. *Decomposes water.*—Take a grain of potassium, wrap it up in a small piece of paper, and introduce it quickly into a glass test tube inverted under water, and consequently full of this fluid. It will immediately rise to the top, and the moment the water reaches it through the paper, part of it will be decomposed, the oxygen combining with the potassium, while an equivalent portion of hydrogen is found in the tube, and may be inflamed in the usual way by applying a lighted match.

419. *Decomposes sulphuric acid.*—Light and heat are also produced by placing a grain of potassium upon the surface of sulphuric acid. This is best done by dropping it into a long tube, holding a little sulphuric acid at the bottom of it.

420. Put 2 grains of iodine in a test tube, about 4 or 5 inches long, throw a grain of potassium upon them, and hold the sealed extremity of the tube for a second or two in the flame of a spirit lamp. The iodine and

potassium instantly combine, a brilliant light is at the same time perceived, and the tube is broken. A glove should be put on while performing this experiment, and the mouth of the tube turned away from the operator. This substance when dissolved in water is called the hydriodate of potassa.

421. *Potassium with sulphur.*—Instead of the iodine of the last experiment, use half a grain of sulphur; the substances will combine with the extrication of light and heat, forming the sulphuret of potassium. The tube is generally broken.

422. *Union of potassium and chlorine.*—Instead of the oxygen, alluded to in *Ex.* 415, use a jar of chlorine. The potassium will be inflamed the instant it comes in contact with the gas, forming by its union with it the chloride of potassium; or in common language, the muriate of potass.

423. *Amalgam of potassium.*—Place a globule of mercury, of the size of a pea, on a piece of writing paper, and bring near to it a globule of potassium of the size of a peppercorn. Touch the paper so that the two metals may come in contact; the instant this takes place, heat will be given out, and they will incorporate, forming a complete amalgam. This amalgam in a few seconds will become solid, although only a small quantity of a solid metal has been used, with double its size of a fluid one. It is by this consolidation and condensation of their particles that the heat is given out, consequently the specific gravity of the new compound is greater than that of the separate bodies.

424. Put the above mentioned solid amalgam into a tea-cup containing warm water. The potassium will here show its greater affinity for oxygen than for mercury, by quickly leaving the latter, which of course sinks to the bottom, and combining with the former, which it takes from the water. The hydrogen will be set free, and the whole action attended with considerable noise. A good method to perform this experiment is, to wrap the amalgam up in a piece of muslin, and suspend it just beneath the surface of water contained in a tall jar, the jar being nearly full. The mercury will be seen to ooze out of the pores of the muslin, and fall to the bottom. A similar effect will take place when this amalgam is exposed to the air, but less rapidly and therefore unaccompanied by noise.

425. *Combustion of potassium and phosphorus.*—Cut a small piece of phosphorus of the size of a split pea; place near it on a marble slab, or still better on a warm iron, a small globule of potassium. Press heavily with the end of a table knife on the two substances together, vivid combustion will take place, and the two substances will unite, forming by the assistance of oxygen from the atmosphere, phosphate of potass.

426. *Combustion of potassium with tin.*—When equal parts of tin and potassium are melted in a crucible, light will be evolved, at the instant of their union, as they form an alloy.

427. *Combustion with arsenic.*—Union but with weaker combustion takes place when potassium and arsenic are heated together. The alloy is arseniuret of potassium.

The following experiments, which were performed by M. Thenard and M. Gay Lussac, exhibit the action of potassium on various salts containing oxygen. In these cases, the potassium displays a greater affinity for oxygen at a higher temperature than any of the other substances employed.

428. *Action with muriate of silver.*—This salt having been fused, and heated to the point of ignition, was pulverized and introduced into a glass tube, into which previously had been introduced a bullet of potassium. The tube was now heated at a lamp: scarcely did the degree of heat applied exceed what was necessary to fuse the metal, when very brilliant inflammation was excited, and the two salts were in consequence reduced. A similar experiment having been performed with muriate of mercury, the phenomena were the same. In both reductions the tubes were fractured; and in that containing muriate of mercury there was a slight detonation, owing to the mercurial vapor.

In these and the following experiments, the heat was somewhat greater than what was necessary to fuse the metal. Sometimes, as for instance, with respect to the decomposition of phosphate of lime, sulphate of barytes, oxyde of zinc, &c., it was carried to 580° of Fahr. thermometer. The tubes employed were always fractured during the inflammation, when it was most vivid.

429. *With salts of barytes.*—When this salt was heated with potassium there was a lively inflammation. Sulphuret of barytes was formed; the oxygen having combined with the potassium. Sulphite of barytes was decomposed without inflammation, and sulphuret of barytes was obtained. It may be concluded from these two experiments that oxygen is much less condensed in the sulphite than it is in the sulphate of barytes, and very probably less in the sulphurous, than in the sulphuric acid.

430. *Sulphate of lime.*—When potassium was heated with sulphate of lime, there was a slight inflammation with the formation of a very yellow sulphuret.

431. *Sulphate of lead.*—When the sulphate of lead and potassium were heated

together, at the instant of decomposition the inflammation was remarkably vivid.

432. *Sulphate of mercury.*—Sulphate of mercury, which was in a slightly oxydized state, being employed, was decomposed with similar phenomena to those exhibited in the decomposition of the muriates of mercury and silver.

433. *Nitrate of barytes.*—A globule of potassium heated with this salt will decompose it so suddenly, and with so much force, as not only to cause vivid inflammation, but also a most violent projection of the materials out of the tube, and in some cases the destruction even of the tube itself.

434. *Chlorate of potass.*—This salt is well known to be one of those employed for detonating purposes. When heated with potassium the inflammation was remarkably vivid, and the expansion so great as to break the tube. The other chlorates, (as that of lime, &c.,) exhibited precisely the same phenomena.

435. *Chromate of lead.*—When potassium and chromate of lead were heated together, a vivid flash announced the decomposition.

436. *Chromate of mercury.*—On heating this beautiful salt with the alkaline metal, the inflammation was certainly not very vivid, but the red color of the salt was instantly converted to green.

437. *Tungstic acid.* — This acid, when heated with potassium, was decomposed with a very vivid inflammation.

438. *Red oxyde of mercury.*—Potassium decomposed this substance with a very vivid inflammation. Detonation also took place, owing to the volatilization of the mercury.

439. *Peroxyde of tin.*—This substance oxydized at a maximum, when heated with alkaline metal, gave out a very bright flame at the instant of decomposition. Oxyde of manganese exhibited similar results.

440. *Oxyde of bismuth.*—When yellow oxyde of bismuth gave up its oxygen to the potassium, the inflammation was remarkably vivid. The gray oxyde of nickel also gave up its oxygen with vivid inflammation.

The following are the phenomena which resulted from the employment of other substances; which, though not so remarkable as the foregoing, are worthy of record :—

441. *Chromate of lead.*—Lively inflammation.

442. *Arseniate of cobalt.*—Lively inflammation.

443. *Protoxyde of tin.*—Flame not vivid.

444. *Peroxyde of iron.*—Slight inflammation.

445. *Oxyde of silver.*—Lively flame.

446. *Red oxyde of lead.*—Like the last.

447. *Yellow oxyde of lead.*—Idem.

448. *Oxyde of copper.*—Lively flame.

449. *Arsenious and arsenic acids.*—Flame.

450. *Protoxyde of cobalt.*—Idem.

451. *Oxyde of antimony.*—Lively flame.

452. *Green oxyde of chromium.*—When this oxyde is heated with potassium there is no inflammation whatever, but a production of blackish matter, which being completely cooled, and afterwards exposed to the air, takes fire, like good pyrophorus, and becomes yellow. This is a combination of potass and the oxyde of chromium, which changes, on exposure to the air, to chromate of potass.

In the following cases there was no inflammation; although the other phenomena exhibited render them worthy of insertion in this place—

453. *Nitrate of potass.*—Destruction of the metal without inflammation.

454. *Phosphate of lime.*—Decomposition, without any appearance of inflammation; the phosphate being converted to a phosphuret.

455. *Carbonate of lime.*—Decomposition, without inflammation; carbon being detached.

456. *Black oxyde of iron.*—No flame, but the oxyde was reduced.

457. *White oxyde of zinc.*—Reduction without flame.

M. Thenard and M. Lussac observe, that they have also traced the effects of the metal obtained from the vegetable alkali upon the earths, and particularly upon zircon, silex, yttria, and barytes; and found that it was very obviously altered by each; but as the cause of this alteration is but little known, they did not enter into any inquiry upon the subject; only that it is very probable that the phenomena observed in burning the metal of potass in silicated fluoric acid gas, depends in no respect upon the silex.

However this may be, it follows, from all the preceding facts, that every substance in which we know oxygen to be present is decomposable by the metal *potassium*, and that almost all such decompositions take place with the disengagement of light and caloric; also that the disengagement is proportionable to the degree of condensation of the oxygen in each body.

SODIUM.

The metallic base of the alkali soda. It is white, of silvery lustre, is soft so that it may be cut a knife, and remains so at the freezing point of water, whereas potassium is brittle at that temperature. It flies off in vapor at a red heat, and quickly tarnishes by exposure to the air, changing into a white powder of caustic soda. It may be prepared in the same way from fused soda, as potassium is from potass; also with the same apparatus. A second method is to partly fill the gun barrel, or retort, with chloride of sodium, (common salt,) and potassium; at a red heat the salt will be decomposed, the potassium uniting with the chlorine, and suffering the sodium to be sublimed, which it will be along with some particles of potassium. To separate this last, digest it in spirits of turpentine, which will wash away the potassium, and leave the sodium pure; it requires a strong fire. Sodium resembles potassium in all its general properties, except that its action is not so energetic; thus, although it rapidly decomposes water, yet does not burst into flame when uniting with it, unless some gum or other mucilage be first dissolved in the water, so as to render it thick. The same experiments given under potassium may be repeated with sodium. The same cautions being requisite in making, keeping, and experimenting with both substances.

LITHIUM.

The metallic base of lithia; a very rare alkali, obtained from two or three different mineral substances. It has not as yet been applied to any use; indeed so small have been the quantities produced, that very little is known either of its properties or combinations. The metal is very similar in general character to sodium; and its union with oxygen a white mass of the nature and character of soda. It is remarkable, however, as being entirely a mineral substance, while potass and soda are both produced by vegetables—and ammonia, the other true alkali, is chiefly an animal production.

CALCIUM. BARIUM. STRONTIAN.

The metallic bases of lime, barytes, and strontian. All we know of these metals are a solitary experiment of Sir H. Davy on each earth. This chemist passed a strong and long-continued current of galvanism through lime, barytes, and strontian, placed in contact with mercury. An amalgam was thereby formed, which, by distillation, afforded in each case a white metal; when this metal was exposed to air, and gently heated, it burnt, and produced the above well-known alkaloid earths. The properties of the metals themselves have not been ascertained.

MAGNESIUM.

The metallic base of magnesia; first procured in the same manner as calcium, &c., by the decomposition of the earth by galvanism. M. Bussy, in 1830, obtained it by a process similar to the preparation of potassium, charging the retort with the chloride of magnesium, (muriate of magnesia,) and potassium, as follows:—

458. *Preparation of.*—Put some globules of potassium into a glass tube, and cover them with the chloride of magnesium broken into small pieces. Let the tube then be heated over a lamp or fire, until the whole begin to fuse; then let the potassium run through the salt by inclining the tube. Light is evolved, and the mass when cold affords, on washing with water, a number of small metallic globules, of a silvery color and lustre, and hard, but malleable; they are not acted upon by water. Heated in the air or in oxygen they burn vividly, and become changed into magnesia.

MANGANESIUM.

This metal, like those formerly mentioned, has so powerful an attraction for oxygen, that it is with difficulty procured in a metallic state, and when thus procured rapidly returns to its state of oxyde, influenced only by the ordinary agents of air and water. It differs, however, from the former metals, in not becoming an alkali when oxydated, but rather assumes an acid character when in its highest state of oxydizement, or that of a simple neutral oxyde when its combining proportion of oxygen is less. It is a hard grey metal, exhaling a peculiar odour when breathed upon or handled—is somewhat brittle, yet will bear filing. It must be preserved under naphtha, in the same manner as potassium.

459. *To procure manganesium.*—Mix a quantity of the carbonate of manganese into a paste with oil, and subject the mixture to a heat gradually raised to redness in an earthen or glass retort, or other close vessel. Suffer the mixture to cool, and then put it into a crucible, surrounding it on all sides with powdered charcoal, ramming the whole well together. Place the crucible thus charged in the strong heat of a wind furnace, where it may become of a white heat. Let it remain so for two hours; upon being taken out, and suffered to get cold, a button of manganese will be found at the bottom of the crucible. Thus made it is not pure, but contains a little carbon and silicium.

460. *Second method.*—Instead of the carbonate of manganese use the tartrate of manganese and potassa, and leaving out the process of mixing with oil or charcoal, place it alone in a crucible, and putting on a cover submit it to an intense and long-continued heat. This method is simple, and procures the metal in considerable purity.

461. *Decomposition of air.*—Let a piece of metallic manganese be left exposed for a short time to the air. It will gradually change into an oxyde abstracting its oxygen.

462. *Decomposition of water.*—Plunge a piece of metallic manganese into a glass of water; it will decompose the water, attracting to itself the oxygen, and suffering the hydrogen to escape; which may be known by applying a lighted taper to the bubbles as they rise to the surface. The action takes place much more rapidly if the manganese be previously heated.

IRON.

This well-known metal is procured from numerous minerals, in which it exists as an oxyde, a sulphuret, or a salt. It is ductile, but cannot be hammered into thin leaves; is tenacious, pliable and capable of being welded; is attracted by the magnet, except when red hot; combustible at a high temperature; fusible at a white heat; and is the only metal which combines with carbon. It is procured as follows:—

463. *Preparation of from clay iron ore.*—The ore is piled up along with billets of wood, coal, or other combustibles, in heaps, 4 or 5 feet high, and many feet in length and breadth. The combustibles being set fire to are allowed to burn for some days, until consumed. This roasting dispels the sulphur and carbonic acid, and renders the ore brittle. It is then broken down, and mixed with certain proportions of charcoal, coke, ordinary coal or anthracite, and limestone, and put into a blast furnace. The following cut will show the construction of the blast furnace, which is about 40 or 50 feet high. A A are the sides of the furnace; they are of fire-bricks, and lined with Stourbridge clay, so as to be capable of bearing the most intense heat without injury. B is a hole made some feet above the body of the furnace, and through one of its walls, for the introduction of the mixed materials. C is the receptacle for the melted metal, and D is a small channel or pipe, connected on the outside with a blowing machine, such as a smith's bellows, and proceeding through the walls of the furnace near to the bottom of the fire.

ZINC, OR SPELTER.

A metal of a blueish white color; tough at common temperatures, but very brittle when on the point of fusion, which is 773°; at a degree of heat a little above that of boiling water it is malleable and ductile, hence it is drawn out into wire, and rolled into sheets, now used for innumerable purposes. When slowly cooled it crystallizes. Exposed to the air it assumes a dull grey appearance from superficial oxydizement, but suffers afterwards little further change; it exists native in the state of carbonate and sulphuret. The former is called calamine—the latter blende.

464. *To procure zinc.*—If blende be used as the source of manufacture, it must be first roasted with a gentle heat to drive off the sulphur. After which the following process is adopted:—The roasted sulphuret or the carbonate, first mixed with one-fifth its weight of charcoal, is placed in a large crucible in a furnace. A second crucible is cemented upon the first, and an iron tube, open at both ends, is made to pass through the bottom of the lower crucible. This tube extends upwards above the contents of the crucible, and through the bars of the furnace to a tub of water, into which the lower end dips. The heat applied decomposes the ore; the charcoal unites with the oxygen, and flies off through the tube, as carbonic acid gas. The metal which is thus set free is also volatilized, and passes down the tube along with the gas, but being condensible by cold sinks to the bottom of the water in the state of impure zinc.

465. *To purify zinc.*—Place the zinc to be purified into an earthenware retort, and apply a strong heat; as soon as fumes arise try their nature by holding a candle to them; if they change of a brown color, they are to

be allowed to escape, as containing cadmium and arsenic. When they burn with a clear blue flame, the beak of the retort is to be dipped under the surface of cold water. The heat being kept up the zinc will distil over, leaving iron, copper, carbon, and other impurities in the retort.

466. *Second method.*—Dissolve common zinc in diluted sulphuric acid; place a piece of metallic zinc in the solution, and leave it for a week or two. Then filter the solution to separate any impurities which the acid may leave undissolved, which appear as a dark powder; then add carbonate of potass to the solution. The sulphuric acid will unite with the potass, and leave the carbonic acid to unite with the zinc, forming the carbonate of zinc. Wash this well in water, dry it, mix it with charcoal powder, and reduce it by a strong heat, in the same manner as in the procuring of the metal in the first instance.

467. *Inflammation of zinc. Philosopher's wool.*—Put some pieces of zinc in a small crucible, put a cover to the crucible, and lute it down with clay, leaving only a very small hole to allow for the expansion of the air within when heated. Imbed this crucible in a common fire, until of a white heat; then taking off the lid of the crucible, the zinc will burst into a most vivid and beautiful combustion; the flame being of a bright, blueish white color. This effect is occasioned by the rapid union of the metal, at a red or white heat, with the oxygen of the air, with which it unites, forming the oxyde or flowers of zinc, which escape in dense white fumes, condensing into a flocculent substance, like wool; therefore called by the old chemists, *philosopher's wool.*

468. The only object of covering the crucible in the last experiment is, because the sudden bursting of the mass into flame renders the effect very striking to a public audience. The cover may be omitted, and the zinc will burn, and become changed into an oxyde, but more slowly. It must be remembered, that as soon as a film of oxyde is deposited upon the surface of the burning metal, the effect will cease until such deposition is removed by stirring. A third method of burning zinc is seen in the next experiment.

469. *To procure zinc in small pieces.*—Melt zinc in an iron ladle; when melted, drop it by little and little into a pail of water, where of course the melted drops will congeal, and may be removed, and kept for future use. When all the metal has been poured from the ladle, turn the dross which remains into the hottest part of the fire. The metallic particles which it contains will burn, and produce a beautiful combustion.

Combustion in oxygen. See *Ex.* 230.

Combustion in chlorine. See 309.

470. *To crystallize zinc.*—Melt 3 or 4 pounds of zinc; pour it into a crucible, which has a small hole at the bottom, stopped with a plug or cork. Watch the time when the surface of the melted metal begins to congeal, and then by means of a wire, or string, pull out the plug, that the metal which is uncongealed may run out; upon afterwards breaking the crust, the inner surface will be found beautifully crystallized; the crystals being of a cubical form and perfectly brilliant. To preserve this brilliancy they must be varnished immediately. By this method the crystallization of almost any metal may be shown.

471. Hold a leaf of white Dutch metal, (which is leaf zinc,) in the flame of a candle or spirit lamp; it will burn with a vivid flame, and as in the other instances throw off its white oxyde.

472. *Detonation of with saltpetre.*—Mix together zinc filings and powdered saltpetre, using about 2 parts of the latter to 1 of the former; take 2 or 3 grains of this mixture, and let them fall into a red-hot crucible or iron ladle. The union of the metal with the salt will be so rapid that a violent detonation will take place, and unless a very small quantity be used the burning matter will be thrown about with violence, to the danger of the experimentalist. The zinc unites with the alkali, forming a soluble substance. Owing to this sudden detonation rather than steady combustion when saltpetre is heated with zinc, the latter is seldom used in fire-works, notwithstanding the vividness of its flame.

TIN.

A white, comparatively soft, flexible, and very malleable metal, which emits a peculiar sound when bent; is of the specific gravity 7·285; fuses at 442°; is volatile at a high temperature, and is very little oxydated by exposure to the air or to water; hence its value in covering pins, nails, wire, and sheets of iron or copper for culinary articles. It is procured chiefly from the peroxyde, which is abundant in Cornwall. This ore is called *stream* tin, from having been subjected to the action of water, it is easily reduced by coal, and gives the purest tin. The metal obtained from the ores of tin found in the mines, and which have not been exposed to water, yields a tin contaminated with antimony, iron, copper, and arsenic. The way in which it is rendered pure is by subjecting bars of this mixed metal to moderate heat, by which a part of the pure tin is first melted, and separates from the less fusible substances. The purer portion is called grain tin, and the other ordinary or block tin. The mass of grain tin is heated till it becomes brittle, and then let fall from a height. By this it splits into irregular prisms, somewhat resembling basaltic columns. This splitting is a mark of the purity of the tin, for it does not happen when the tin is impure.

Ex. 473. *Crackling and latent heat of tin.*—Take a piece of grain tin; bend it quickly, holding it at the same time to the ear—a very peculiar crackling sound is heard. This distinguishes tin from all other metals. Bend it backwards and forwards several times quickly, when so much heat will be extricated that the tin can scarcely be held in the hand.

474. *Smell of tin.*—Let a piece of grain tin be rubbed by the hand, or held in the warm hand for a few minutes; it will communicate a very peculiar smell. This is very apparent in a tinman's shop where several persons are at work upon the metal. In this case the air imbibes the odour.

The tin tree. See *Ex.* 124.

Tinning tacks, pins, &c. See *Ex.* 138; also the next chapter.

Note.—Tin foil, so much used for covering electrical jars, and for other similar purposes, for the amalgam of looking glasses, &c., is merely tin, beaten out into thin leaves. The thinnest leaves are about one-thousandth of an inch thick. This substance is admirably adapted to wrap round mosses and other small plants, which are to be sent in letters to a distance.

475. *To reduce tin from its oxyde.*—Mix 120 grains of the oxyde of tin, (putty powder,) with 20 of the carbonate of potass and 16 of soda, which has been previously heated till it becomes a white powder, in consequence of losing its water of crystallization. Expose the mixture to a good heat, in a crucible placed in a furnace for 20 minutes. The carbon unites with the oxygen of the oxyde, and flies off as carbonic acid gas, while the metallic tin remains at the bottom of the crucible.

476. *To reduce it to a finely-divided state.*—Melt the tin, and pour it while fluid into a wooden box; the inside of which has been rubbed with chalk. Shake it up quickly, and when cold it will be in a state of minute division.

477. *Second method.*—Melt tin in a ladle, and when melted stir it with an iron rod, continuing the operation till it solidifies. It is better done in a hot mortar, and pounded with a hot pestle. By either method the finer powder is to be sifted away from the coarser.

478. *Moirèe metallique: Metallic watering, or crystallized tin plates.* This art was much practised some years since to ornament the surface of articles made of tin plate, or covered with tin foil. The plate of tin is to be taken up by one corner with a pair of pincers, and put on or before a clear fire, until so hot that a drop of water let fall upon it will boil. Then wash over one surface of the plate with a mixture of 4 parts water, 1 nitric acid, and 1 hydrochloric acid. Then dip the plate in water to clear off the acid adhering to it, when it will be seen to have a beautiful crystallized appearance all over the surface. The figures may be infinitely varied by making one part of the plate hotter than the rest. The beautiful colors sometimes given to these crystallized articles is obtained by transparent varnishes laid on afterwards. Columns for various internal decorations and other articles of an irregular form are covered with thick tin foil, rendered crystalline by the same method; the tin foil being heated by laying it on a plate of iron.

479. *Crystallization of tin.*—Melt 4 ounces of grain tin in a clean crucible; when in a fused state immerse a thick iron wire in it. Take it off the fire, and let it cool until a hardened covering be formed on the top, the thickness of a halfpenny. Now withdraw the wire, and pour out through the aperture all the fluid tin beneath. When the crucible is quite cold, break it, and take out the hardened covering. The under surface will be found in a state of the most beautiful crystallization.

Combustion in oxygen. See *Ex.* 229.

480. *Combustion in the air.*—Let a globule of tin, melted to a white heat, be suffered to fall upon a sheet of paper; it will break into smaller globules, and burst into a bright white flame.

CADMIUM.

A white, malleable, and rather hard metal; much resembling tin in its general principles. Of the specific gravity 8·60; unalterable in the air at usual temperatures. Fuses at 442, and distils over at a heat somewhat below redness, condensing into metallic globules. No state of the metal or its combinations have hitherto been applied to medicinal purposes, nor in the arts. It is extremely rare, and obtained from certain ores of zinc, especially the black fibrous blende of Bohemia, and the calamine of Derbyshire.

Ex. 481. *To obtain cadmium from calamine.*—"Pulverize the ore, and digest it for some hours in hydrochloric acid, by which a mixed chloride of zinc and cadmium is obtained. It should be evaporated to dryness, to drive off excess of acid, and re-dissolved in water. Immerse a plate of iron in this solution, to separate all that may be thus precipitated, and afterwards filter the liquor into a platina capsule, containing a piece of zinc. The cadmium will coat over the surface of the capsule, and adhere so firmly to it, that it may be washed, and thus freed from any remaining solution of zinc. Hydrochloric acid dissolves the precipitate with effervescence, and from this solution it is thrown down white by the alkalis, and yellow by sulphuretted hydrogen."—*(Dr. Wollaston.)* It may be reduced to the metallic state by mixing the oxyde thus formed with charcoal, and applying a red heat in a tube or retort, when the cadmium being volatile at that temperature sublimes.

COBALT.

A metal of a reddish-grey color; hard, brittle, and fused with difficulty. Being rarely used in a metallic state, its manufacture is very limited, and conducted only on a small scale. It may be made as follows:—

Ex. 482. *Preparation of cobalt.*—Dissolve zaffre or smalt, which is an oxyde of the metal united with silex, in dilute hydrochloric acid to which is added a little nitric acid. Sulphuretted hydrogen is made to pass through the solution contained in a Woolf's bottle, (see *Ex.* 285,) by which arsenic is precipitated. The filtered liquor may then be boiled with a little nitric acid to peroydize the iron, and precipitated by carbonate of potassa. The precipitate, when well washed, is to be digested in oxalic acid, which uniting with it forms an insoluble oxalate of cobalt. This being placed in a crucible, and submitted to a high degree of heat, is reduced; the oxalic acid flying off, and the cobalt being left in the state of a black powder at the bottom of the crucible. To fuse it into a metallic state an intense white heat is required.

483. *Second method.*—Put into a crucible 1 ounce of zaffre or smalt, ¾ of an ounce of soda, and the same quantity of charcoal. Give this a strong white heat for two or three hours, the metal will be found reduced at the bottom of the soda. Here the silex of the smalt combines with the soda to form glass. The oxygen of the oxyde of cobalt unites with the carbon or charcoal, and flies off as carbonic acid gas; while the metal is reduced.

NICKEL.

Nickel was discovered in 1751. It is found native, and combined with arsenic and with arsenic acid. It is white, brilliant, ductile, malleable, of the specific gravity of 8·5; acts upon the magnetic needle, and is itself capable of becoming a magnet, though feebler than one of iron. Not altered in the air or water, but when heated it acquires various tints, like steel. It has been much used of late years in the manufacture of German silver. (See *Alloys.*)

Ex. 484. *Preparation of.*—Dissolve the impure metal, which is sold under the name of speiss, and which is an arseniuret of nickel, in sulphuric acid, adding a little nitric acid. Concentrate this solution, and set it aside to crystallize; fine green crystals of sulphate of nickel will be deposited. Dissolve these crystals in water, and crystallize a second time. Dissolve a third time, and pass sulphuretted hydrogen through the solution, to deposit any arsenic or copper that may be present; re-crystallize, dissolve in water, and add potass to the solution. A pure oxyde of nickel and cobalt will subside; to separate the latter, wash the oxyde, and pass chlorine through its solution. This will throw down the cobalt, and a solution of chloride of nickel will be obtained; this will be thrown down by potass, or if intended for the production of the metal, by the oxalic acid in the state of oxalate, which is then dried, and heated to a high temperature in a covered crucible; or the oxyde may be reduced by being made into a paste with oil and charcoal, and submitted to a white heat.

485. *Burns in oxygen.*—Reduce nickel to coarse powder; place it on a piece of charcoal, (as recommended in *Ex.* 225,) and throw a stream of oxygen gas upon it; it will burn in the same beautiful manner as cast-iron nails. So also fine particles of nickel dropped into the flame of a candle take light.

COPPER.

This well-known metal was one of the first employed by mankind, and long before iron was known. It is found native, and in numerous states of combination; it has a red brilliant color, is malleable and ductile; melts at a dull white heat, and is of the specific gravity of 8·86. The copper of commerce usually contains a little iron. It is obtained perfectly pure by the following method:—

Ex. 486. *Purification of copper.*—Dissolve ordinary copper in nitric acid; dilute the solution, and immerse a plate of iron—the copper will be precipitated upon it. Wash the substance thus obtained in dilute sulphuric acid, to separate a little iron that may adhere, and melt in a crucible.

487. Into a solution of sulphate of copper, (blue stone,) put a piece of zinc, and let it remain for some considerable time. This metal, having a greater affinity for sulphuric acid than copper has, will decompose the sulphate, taking to itself the acid, and therewith forming sulphate of zinc, (white vitriol,) while the copper falls to the bottom of the vessel in a state of a fine metallic powder.

488. *To granulate copper.*—Fuse it in a crucible, and let it fall by drops into hot

water, through the bottom of a perforated ladle. The copper will form small round shots, called *bean shot*. If the water be cold, and kept so, the copper forms ragged pieces, called *feathered shot*.

Combustion in chlorine. See *Ex.* 309.

LEAD.

This metal, known in the earliest ages of the world, and still one of the most important and most abundant, existing in numerous states, particularly in that of a sulphuret, called galena, from which the metal is chiefly procured. It is of a blueish white color, flexible, soft; leaves a black streak upon paper; fuses at about 612°, and by the united action of heat and air is rapidly converted into an oxyde. Its specific gravity is 11·4.

Ex. 489. *Manufacture of lead on a large scale.*—Reduce galena to coarse powder, and expose it to heat in a reverberatory furnace, adding portions of coal and limestone from time to time. The lime withdraws the sulphur, now converted by the heated air into sulphuric acid. The carbon of the coal takes oxygen from the oxyde that is also formed, disengaging metallic lead; or oxyde of lead and the sulphuret re-act on each other, giving metallic lead and sulphurous acid. The following cut will explain the nature of a reverberatory furnace:—A is the fire and ash-hole. B a hole through the side wall for the admission of fuel. C part of the furnace, which reverberates the heat from the sides and top, and so on to the crucible placed at E. D is the chimney, in which is inserted a moveable damper to regulate the heat. There is a hole through the side of the furnace, opposite E, for the placing and withdrawing of the crucible.

To separate lead from silver. See *Silver.*

490. *To obtain lead minutely divided.*—Heat to redness in a covered crucible, either the tartrate or the acetate of lead, (sugar of lead.) The lead thus obtained is in a state of extremely minute division, and mixed with a little carbon, derived from the decomposition of the acid. In this condition it bursts into flame spontaneously when brought into contact with the air.

491. *To obtain pure lead.*—Dissolve common lead in nitric acid, and evaporate the solution to dryness; re-dissolve the dry mass in water, and crystallize. Place the crystals thus prepared in a ladle with charcoal powder; at a red heat they will be decomposed—the nitric acid fly off, partly in the state of nitrogen, and partly in carbonic acid gas; its oxygen combining with the carbon, and forming this gas, while metallic lead in a perfectly pure condition will be found at the bottom of the crucible.

The lead tree. See *Ex.* 123. *Note.* The lead precipitated on zinc is perfectly pure.

492. *Burns in oxygen.*—Place some cuttings of lead on ignited charcoal, as in *Ex.* 225. Upon throwing a stream of oxygen upon it, the metal will burn of a beautiful blue flame.

Combustion in chlorine. See *Ex.* 309.

ANTIMONY.

This metal is of a silvery white color; brittle and crystalline in its ordinary state. It fuses at 800°, and has a specific gravity of 6·712. It is procured chiefly from the sulphuret, which is a rather abundant mineral, particularly in the Hartz mountains. It is also found native in Sweden and France. Antimony is used chiefly in union with other metals.

Ex. 493. *To procure antimony.*—Reduce the sulphuret of antimony to a powder, and add to it two-thirds its quantity of crude tartar. Mix them together; throw the mixture by spoonsful into a red hot crucible—then heat the mass to redness, and a button will be found at the bottom of the crucible, which is the metal as it commonly occurs in commerce, and is nearly pure. Reduce this button to fine powder, and dissolve it in nitro-muriatic acid; pour this solution into water, which will occasion the precipitation of a white powder, which is to be washed and mixed with twice its weight of tartar, and exposed to a dull red heat in a crucible. The button now obtained is pure antimony.

Combustion in chlorine. See *Ex.* 308.

494. *Combustion in oxygen.*—Perform *Ex.* 230 with antimony, instead of zinc. The combustion will be vivid, and the flame of a pure white color.

BISMUTH

Is sometimes found native, but more usually united with oxygen, and with arsenic and sulphur. It is brittle, and of a whitish red color; fuses at 476°, and crystallizes on cooling. Its specific gravity is 9·822. To obtain it pure, dissolve the bismuth of commerce in nitric acid; add water to the nitric solution, which separates sub-nitrate of bismuth. This compound is easily reduced in a crucible, with charcoal or with borax. Bismuth is used in union with other metals, to which it communicates the peculiar power of melting at a degree of heat much less than the average of their melting points. See *Fusible Alloys.*

Crystallization of. See *Ex.* 195.

URANIUM, TITANIUM, CERIUM, TELLURIUM, MOLYBDENUM, CHROMIUM, VANADIUM, TUNGSTEN, AND COLUMBIUM.

These metals are of such uncommon occurence, that they are not employed in the arts, and scarcely even as chemical tests. The same reason prevents them from being the subject of frequent experiment. They are all extremely stubborn in the fire. Such combinations of them as are valuable will be described in the next chapter.

ARSENIC.

This metal is very peculiar in its properties, particularly in all its compounds with oxygen being of an acid character. It cannot be fused in the open air, but volatilizes at a low degree of heat, (about 360°.) Its vapor has a peculiar and disagreeable odour, like that of garlic, and by which this metal may at all times be known from others. In its metallic state it is of a grey color like iron, of crystalline texture, quite brittle, and of the specific gravity of 5·8. The metal and all its compounds are virulent poisons.

Ex. 495. *To procure arsenic.*—Heat in a retort the native ore of arsenic, broken into small pieces, the metal sublimes, and is condensed in the neck of the retort.

496. *Second method.*—Introduce into a Florence flask some of the common white arsenic of the shops, previously mixed with twice its weight of charcoal. Place the flask in a sand bath, and increase the heat until the flask and contents are red hot. The pure metal will sublime, and be deposited in a brilliant metallic state in the upper part of the flask. A retort may be used for the same purpose, or even a glass test tube, if wanted for a class experiment, when not more than a quarter of a grain of the mixture need be used. The medical student should repeat this experiment frequently, in order to detect arsenic by this means from very small quantities of ingredients, as is often necessary to him. See *Arsenious Acid.*

497. *Volatilization of.*—Put a grain or two of metallic arsenic on a plate of iron, and expose it to heat; the arsenic is speedily volatalized, producing a strong and very peculiar odour. At the same time a portion unites with the oxygen of the air, and produces arsenious acid, or white arsenic, which escapes in the state of white fumes, the crystals of which, if collected in a tube, are very brilliant.

498. *Burning of arsenic.*—Throw a few grains of powdered arsenic into a red-hot crucible. It will burst into a flame of a bright blue color, and continue to burn until consumed or volatilized.

499. Mix a few grains of metallic arsenic with twice its weight of gunpowder, and once its weight of saltpetre. Grind them well together, and set fire to the mixture. It will burn with great splendour, producing a whitish blue flame. On account of this effect, metallic arsenic is often used in fireworks to produce a strong white fire. Realgar which is the proto-sulphuret of arsenic is also used for the same purpose. See *Compounds of Arsenic.*

Combustion of in oxygen. See *Ex.* 231.

Combustion in chlorine. See *Ex.* 305.

500. When finely powdered arsenic is boiled in a solution of potass, hydrogen is evolved, and the metal acidified; this arises from the decomposition of the water, but when arsenic and potass are heated together without water, a brown compound is obtained, which appears to be a mixture of arseniuret of potassium, and the arseniate of potass. Here the metal arsenic deprives the potass of part of its oxygen, becoming arsenic acid, when it unites with the undecomposed portion of the potass to form the arseniate. The potassium thus set free unites with the rest of the metal arsenic, forming an alloy of the two metals, or the arseniuret of potassium.

MERCURY.

A brilliant white metal; fluid at ordinary temperatures; solid at 40° below zero Fahr., contracting considerably at the time of congelation. Boils and sublimes at 670° It is found in a metallic state in small fluid globules, and also still more abundantly as a sulphuret.

Ex. 501. *To procure mercury.*—Pound some vermillion, mix with it an equal weight of charcoal powder; place this mixed powder in an earthenware retort, and submit it to a red heat. The metal will sublime, and run down the neck of the retort into any vessel placed to receive it.

Distillation and Purification of. *Ex.* 167.

Precipitation of mercury. *Ex.* 121.

Combustion of in chlorine. *Ex.* 300.

502. *Combustion of in oxygen.*—Put a large globule of mercury in an iron deflagrating spoon. Heat it until red hot, when it will

begin to evaporate. In this state immerse the spoon in a jar of oxygen gas, and the metallic mercury will burn with a flame of a bright blue color.

503. *Freezing of mercury.*—Pour 2 or 3 drams of mercury into a glass tube, and place it in a freezing mixture of 2 parts of snow or pounded ice, and 1 of chloride of soda, (common salt.) This will reduce it to zero, or 32° below the freezing point of water; take the tube from this mixture, and immerse it immediately in another, composed of 4 parts of snow, and 5 of the chloride of lime. The mercury in the tube will be frozen into a solid mass of a crystalline structure. If the tube be broken to extricate the mass, the solidity and crystallize character will be evident. Frozen mercury is specifically heavier than fluid mercury, consequently, it will sink in it. It also when suffered to touch the flesh produces the same effect as a piece of red hot metal, destroying the skin, and giving the sensation of a burn. The *rationale* of this effect is as follows:—The frozen metal receives caloric so energetically from the flesh, that the skin is destroyed by the rapidity of the metal's absorption. In the case of the heated metal, the skin receives caloric with equal rapidity, and the skin is equally destroyed.

504. *To purify mercury by filtration.*—Mercury is often contaminated with dust, and an oxyde which settles on its surface. To remove this is very necessary to the looking-glass manufacturer. It may be done by preparing a cone of thick paper, in the manner of a filter, making a hole with a pin at the apex. The mercury being poured in will ooze through, leaving the oxyde and other pulverulent impurities on the surface of the paper. If the metal be pure, the surface will remain bright; if it be contaminated with lead or tin, a second coat of oxyde will almost immediately form.

505. *To purify a small quantity of mercury.*—(Dr. Priestley's method) "Put the mercury in a phial, capable of holding 4 or 5 times the quantity, shake it briskly, blowing into it occasionally with bellows to renew the air, and continuing till a black matter gathers together, which may be easily separated from most of the metallic mercury by a paper funnel as before directed; after this it should be returned again, and the operation repeated, till no more oxidation takes place, when the mercury becomes extremely clean; the brightening taking place all at once, as the last portions of the other metals are oxidated.

506. *To purify it by an acid.*—Nitric acid dissolve mercury, yet not so readily as it does tin, lead, and zinc, metals with which mercury is often contaminated, either naturally, accidentally, or for the purpose of adulteration. To remove this, the impure mercury may be placed in a phial along with a *small* quantity of nitric acid, and shaken up; this acid will immediately attack the solid metals. When they are dissolved, the acid may be poured off, and the mercury washed in water to remove any adherent acid, it will be then quite pure.

507. *Union with other substances.*—By triturating metallic mercury with chalk, manna, sugar, lard, and a number of animal and vegetable substances, the metallic globules disappear, and a mass is obtained of a dark color. Many consider the metallic mercury to be merely reduced to a very minute state of division in this manner, while others affirm, that it is at the same time oxidated.

SILVER

Is white, brilliant, malleable, ductile, of the specific gravity of 10·5, melts at a bright red heat,—does not oxidize by exposure to the air, or to water, unless containing sulphur,—exposed to an intense white heat, it boils and evaporates. If suddenly cooled, it crystallizes during congelation, often shooting out like a cauliflower, and throwing small particles of the metal out of the crucible.

Ex. 508. *Silver obtained from its ores.* The ore is reduced to powder by machinery, and then agitated with mercury and water in a barrel. The mercury combines with the silver, and forms an amalgam, which is separated from the stony matter, and the mercury is then removed by distillation, the silver being left.

509. *Silver obtained from the sulphuret.*—Break the sulphuret to pieces, and heat it in a reverberatory furnace along with common salt; chloride of silver, which is a white insoluble powder, will be thus obtained. This is to be agitated in barrels with mercury, water, and fragments of iron, the iron removes the chlorine, and is dissolved in the water, while the mercury combines with the silver, forming an amalgam, which being distilled gives up the mercury, and leaves the silver.

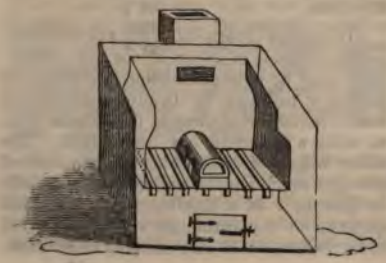
510. *Silver procured from the chloride.*—The chloride of silver of the last experiment may be reduced without mercury, by boiling it in water for two or three hours, with a tenth part its weight of metallic zinc, to which a little acid has been added. The silver will be deposited as an ash-colored powder, which may be melted into a globule by heating it in a crucible, adding a small quantity of the carbonate of potass or of soda. Chloride of zinc remains in solution.

511. It may also be obtained by heating the chloride in a crucible, along with lime and charcoal, using 20 parts of pure lime and 4 of charcoal, to every 100 parts of the chloride. Metallic silver will be found at the bottom of the crucible.

512. *To purify silver when mixed with copper.*—Digest the impure silver in a mixture of 8 parts of sulphuric acid and 1 of nitre; this assisted by a litttle heat will dissolve the silver and not the copper. The solution being poured off, common salt is to be added to throw down the chloride of silver, which may be reduced as before directed. In this manner the covering of silver is removed from plated goods.

513. *To purify silver when mixed with lead by cupellation.*—Fill a crucible or ladle with ivory black, and burn it on the fire; the result will be a white powder, consisting chiefly of phosphate of lime, make this into a thick paste with water, and form it by the hand into the shape of a shallow cup, called a *cupel*, of which A in the following cut is a longitudinal section. It may be 2 inches wide, and nearly 1 deep. Place a small quantity of the impure metal in the cup, and expose it to a strong heat in a *muffle*, which is an earthenware vessel of the form B, taking care that the muffle be exposed to a current of air. The metal will melt, and the lead be absorbed by the cupel, while the silver will remains pure. The instant that the whole of the lead is absorbed, the silver will become excessively brilliant. This peculiar effect is called *fulguration*, and only takes place the instant that the metal has become pure. Silver may be purified from contamination with copper by the same means.

The above experiment may be conducted in an open fire-place, supporting the muffle on a piece of brick. But if to be performed on a large scale, a cupellation furnace is requisite. The construction of this will be easily understood, from the preceding cut, where a muffle is seen resting on two supports.



The silver tree, or *Arbor Dianæ*. See *Ex.* 125, 126, 127. 130, and 131.

Silvering clock-faces, &c. See *Ex.* 132.

Silvering plates for the Daguerreotype. See *Ex.* 19.

Silvering ivory. See *Ex.* 134.

Silvering by hydrogen. See *Ex.* 253.

Silver burns in chlorine. See *Ex.* 302.

GOLD.

Gold is found in a metallic state, alloyed with a little silver and copper, and in this state it is called *native* gold. It is of a deep and peculiar yellow color, melts at a bright red heat, equivalent to 2016° of Fahr. thermometer, and when in fusion, appears of a bright green color. Its specific gravity is 19·5. Gold is so malleable that it may be extended into leaves which do not exceed the two hundred and eighty-two thousandth of an inch in thickness, or a single grain may be extended over 56 square inches of surface, and so ductile, that the same small quantity may be drawn into 500 feet of wire. It does not unite with oxygen when heated in that gas.

Ex. 514. *To obtain pure gold.*—Dissolve some gold-leaf in three times its weight of nitro-hydrochloric acid, composed of 1 part by weight of nitric, and 2 of hydrochloric acid, evaporating the solution to dryness, by a gentle heat towards the end of the operation. Re-dissolve the dry mass in distilled water, filter, and add to it a solution of sulphate of iron, a black powder falls, which, after having been washed with diluted hydrochloric acid and distilled water, affords on fusion a button of pure gold. For the purpose of solution, it may be kept in the pulverulent state.

515. *Solution of gold.*—There are three solvents for gold, aqua-regia, or nitro-hydrochloric acid, aqueous chlorine, and a mixture of the chromic and hydrochloric acids; this last mixture, as well as chlorine, is inconvenient and uncertain, but the nitro-muriatic acid dissolves it very readily, forming with water a solution of almost the only salt of gold, though the metal unites with several of the elements,—oxygen, bromine, iodine, &c.

516. *Æthereal solution of gold.*—To the above solution add sulphuric ether, this will separate the gold from the acid, and the ether holding the gold in solution will float upon the surface of the acid, from which it may be poured off, and kept for use in a

dark place or an opaque bottle, it being decomposed by light.

517. *Precipitation of gold upon charcoal.*—Put ½ an ounce of diluted nitro-chloride of gold into an ale glass, and immerse a piece of very smooth charcoal; expose the glass to the rays of the sun in a warm place. The charcoal will very soon be covered over with a very beautiful golden coat. In this experiment it is supposed that the precipitation is occasioned by the decomposition of the acid by the sun's rays.

518. *Ditto by heat alone.*—Immerse a slip of charcoal in a phial, containing nitro-hydrochloride of gold; expose this to a considerable heat; first gradually to prevent breaking, and then either by immersing the phial in a vessel of boiling water, or in a sand bath. In either case the charcoal will be coated with gold.

Combustion of gold leaf in chlorine. See *Ex.* 302.

Gilding by hydrogen. See *Ex.* 251, 252.

Gilding by phosphorus. See *Ex.* 405.

519. *Gold powder.*—Put into an earthen mortar some gold leaf, with a little honey or thick gum water, and grind the mixture, till the gold is reduced to extremely minute particles; when this is done, a little warm water will wash out the honey or gum, leaving the gold behind in a pulverulent state.

520. *Second method.*—Add to the nitro-chloric solution of gold, obtained by *Ex.* 508, a little of the solution of sulphate of iron, metallic gold will be deposited in the state of a fine powder. It must be well washed before using. This powder has no metallic lustre until rubbed.

521. *Color of gold by transmitted light.*—Hold a leaf of gold up to the light, and look through it at a bright object such as the sun, the light seen through the gold leaf will appear of a fine green color.

PLATINUM.

Platinum is found in a metallic state, occasionally pure, but more usually mixed with numerous other metals, the commoner of which are gold, iron and lead. Its chief source of supply is the Uralian mountains of Siberia. It is a white metal, ductile, extremely difficult of fusion, and unaltered by the joint action of heat and air. Its density is about 21·5. The resistance it offers to heat renders this metal invaluable to the chemist for crucibles and other vessels, for wire, foil, &c. It is also much used for the touch-holes of fire-arms.

Ex. 522. *To procure platinum.*—The following process is given in Reid's "Chemistry," for this purpose,—observing that the only solvent of platinum is the aqua regia, or nitro-hydrochloric acid, as it is also for gold. Dr. Reid says, "The hydrochloric acid employed for the aqua regia used, is to be prepared by mixing equal measures of strong hydrochloric acid and water, and the nitric acid should also be diluted; aquafortis, termed also single aqua-fortis, is what Dr. Wollaston recommends. The platinum is digested for 3 or 4 days in the acid liquor, with a heat gradually increasing, the solution is then decanted, and allowed to stand till a quantity of a fine powder, containing irridium, has subsided. It may then be mixed with a solution of 41 parts of hydrochlorate of ammonia in 205 parts of water. The yellow precipitate that is thrown down, must be well-washed, and ultimately pressed to remove adhering impurities. On exposing it to heat, metallic platinum is left, in a state of very minute division, the hydrochlorate of ammonia and chlorine being expelled."

523. *To make spongy platinum.*—Dissolve the metallic powder obtained by the last experiment, in the same mixture of acids as before, and precipitate the platinum in like manner by the hydrochloride of ammonia diluted. The yellow precipitate which falls, or the ammonio-chloride of platinum, is to be heated in a covered crucible; the grey mass left is *spongy* platinum, and which becomes incandescent, when exposed to a stream of hydrogen, as explained in *Ex.* 267. This spongy platinum is usually made up into small balls about the size of a pea, with one-third its weight of fine clay, moistening the mixture and slowly drying it afterwards. These balls should always be kept perfectly dry, and if for an experiment for the lecture table, where success should be certain and rapid, it is better to heat them nearly red-hot in the flame of a spirit lamp previous to using.

524. *Ditto, second method.*—Pleischl has recommended another mode of preparing spongy platinum. Blotting paper is wetted 3 or 4 times with a saturated solution of platinum, in aqua regia, drying it between each immersion. Burn the paper, and the ashes which are left constitute the platinum in a finely divided or spongy state.

525. *Third method.*—Spongy platinum may also be made by dissolving a piece of platinum wire, or foil, in the nitro-hydrochloric acid, precipitating it and heating the precipitate as before.

526. *Fourth method.*—Fuse crude platinum with twice its weight of zinc, reduce the alloy to powder, and then digesting it

first in diluted sulphuric acid, and afterwards in dilute nitric acid, assisting the operation by heat. The zinc being removed by these acids, the metallic platinum is left as a dark grey powder, in a minute state of division, but impure. It is then heated with a solution of potass, and afterwards washed with water, when it is fit for use, and will be found extremely active.

527. *Red hot platinum decomposes oils, spirit, &c.*—The peculiar property of platinum in continuing incandescent, when exposed to certain vapors, is shown not merely by spongy platinum, but by the metal when in a concentrated metallic state. This may be tried as follows:—Make a small coil of fine platinum wire, and place it by means of the ends of the wire, which have been left loose, into the wick of a spirit lamp, filled with alcohol; set fire to the wick, and when it has burnt 2 or 3 minutes, blow out the flame, the platinum wire will continue red hot until the whole of the spirit be exhausted. It should be covered loosely with a glass funnel, so that air should have access to it, yet no current be sufficient to rob the platinum of its heat. The same would be the case with oil, and is taken advantage of in the miner's lamp, to renew the flame to the wick, on emerging from an atmosphere which will not support combustion, and which the miner may have entered.

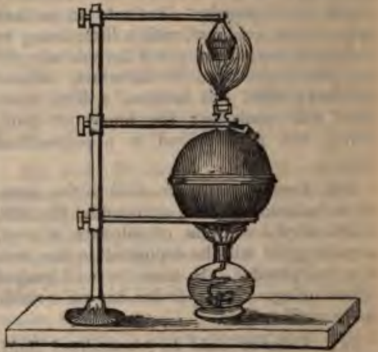
528. *Absorbent of oxygen.*—Fill a dry phial with oxygen gas, drop into it some spongy platinum, put the stopper into the phial, and set it aside for some days, then dip the mouth of the phial beneath the surface of water, and withdraw the stopper while there,—the water will ascend into the phial, and quite fill it; the platinum having absorbed the whole of the oxygen, provided the gas be not more than 100 times the bulk of the metal. (Some chemists say 200 times.) In this experiment there is no oxidation takes place, but the effect is analogous to the absorption of many gases by carbon as already described. *Ex.* 349, 350 and 351.

529. *Ethereal solution of platinum.*—Proceed as in *Ex.* 516, using the bichloride solution of platinum, (that obtained by dissolving the metal in aqua regia) instead of the bichloride solution of gold, the result will be a solution of this metal in ether.

To platinize brass, copper, &c. See *Ex.* 136.

530. Place a particle of lead, tin, or antimony on a piece of platinum foil, and heat it over a spirit lamp; when at a red heat, the metal used, whichever it may be, will combine with the platinum, and forming a fusible alloy, will run down. This experiment shows that the above metals must never be melted in platinum vessels; the same holds good with the ores and oxydes of these metals, and in a less degree with bismuth, copper, cobalt, and nickle. The following cautions are added by Berzelius:—they must not be subjected at any time to the action of chlorine, nor the compounds which evolve chlorine. Nitre and the alkalies must not be fused in them. Immediate contact with the fuel, (which ought to be charcoal, if in a furnace,) must be avoided as much as possible.

Note.—The best method of heating platinum capsules, is by a spirit lamp. If the heat given by an ordinary lamp be not sufficient, a most powerful flame may be produced by placing over the spirit lamp a second vessel, made of tin or other vessel, with a small orifice at the top, this is partly filled with alcohol; when the ignited lamp is placed beneath it, the alcohol boils, and the steam rushing out of the orifice, may be inflamed, when the platinum capsule suspended over it, will very soon become red hot. The following cut will exemplify this powerful and simple apparatus.



PALLADIUM, RHODIUM, OSMIUM, AND IRRIDIUM.

These four rare metals are of a whitish color, very refractory in the fire, of difficult solubility in acids, and obtained from the ores of platinum, with which they agree in general characters. They are too rare and intractable to be made of service in the arts, or the subject of experiment.

GLUCINUM, ZIRCONIUM, YTTRIUM, THORINUM, AND ALUMINUM.

These metals differ from those previously mentioned in forming earths, when united to oxygen. The two first are obtained from precious stones, the one (called also berillium,) from the beryl, and the emerald; the other from the zircon or hyacinth; yttrium, and thorinum, from rare minerals. The oxyde of aluminum is extremely abundant throughout the world, existing in the state of clay, alum, the sapphire, ruby, topaz, emery, &c. All these metals have the same general properties. Their rarity prevents any general use being made of them, even did their properties allow more general application of them to the purposes of the arts. The metal aluminum, of which the few following experiments are given, will suffice to illustrate this the most common of the earthy metals.

Ex. 531. *Preparation of.*—To Wöhler we owe the following ingenious method of preparing aluminum. " Chloride of aluminum is heated with potassium in a small platinum crucible, the heat of a spirit lamp is sufficient, for when the substances begin to act, the temperature suddenly rises to redness, and care should be taken so to adjust the proportion of materials, that none of the chloride may be evaporated in an undecomposed state, while at the same time there should not be an excess of alkali in the residue. When the crucible is cold, its contents are well washed with cold water, by which a finely divided grey substance, with a certain degree of metallic lustre is obtained, which is pure aluminum."—*Brande's Chemistry.*

532. Expose some aluminum to heat in a crucible; when red hot, it attracts oxygen from the air, burns with great brilliancy, and becomes changed into alumina, which when cold form a hard, white substance of precisely the same nature as burnt tobacco pipes, or white crockery ware.

533. Suffer some of the powder of aluminum to fall into the flame of a lamp or candle. It will while passing through the flame, burn with very considerable brilliancy.

534. Place a piece of aluminum in an iron spoon, heat it red hot, and while in that state, immerse it in a jar of oxygen, when it will burn with considerable brilliancy, and become an exceedingly hard mass of fused alumina.

SILICIUM, OR SILICUM.

The base of silica or flint. It is a matter of doubt if this body be metallic or not, it much resembles boron in its nature. It has no metallic lustre, does not conduct electricity. It is a dark solid, of a brownish color, incombustible, and not easily oxydated, except by deflagration with the carbonate of potass or soda, when it becomes silica, and remains in union with the alkali. It was prepared by Berzelius by the action of heat upon a mixture of potassium, with the fluoride of silicium and potassium. The process is difficult, and the material when prepared useless; those who desire the exact account of its manufacture may consult Brande's " Chemistry."

CHAP. IV.

COMPOUND SUBSTANCES, ALLOYS, AND AMALGAMS; LAWS OF CHEMICAL COMBINATION, AFFINITY, &c. OXYDES, CHLORIDES, SULPHURETS, CARBURETS, SALTS, COMPOUND GASES, &c.

As the above-described elements are all the distinct substances which are known to exist, it follows that all compounds of whatever nature they are, must be composed of these elements, however much their properties may differ from the elements themselves. For example, gum, oil, sugar, wood, and resin, are totally distinct from each other, neither does either one of them resemble oxygen, hydrogen, or carbon; yet they are all composed of these three elements, united together in a different manner or in different proportions. It is the object of chemistry chiefly to explain the nature of such combinations, and the laws which govern them; the elements themselves being but materials to work with, and although some of them, as sulphur, carbon, and the metals are valuable in their uncombined state, yet as it relates to others wholly, and to these even in a great degree they are still more valuable in their compounds. It has been explained in Chap. I, that all substances do not unite chemically, and those which do so are much affected by temperature, by contact with the air, the presence of moisture and other causes. It might have been shown also that bodies unite only in certain proportions. Thus in making soda water with tartaric acid and the carbonate of soda, if the acid be not sufficient to saturate the whole of the soda, the liquid will still taste alkaline; if too much acid be used, it will taste sour. It is only a portion therefore of the soda which has been neutralized in the first instance, the rest of it being unaltered by the acid; in the last case, the superfluous acid has nothing wherewith to combine. In fact, an exact quantity of each is necessary to neutralize the other, so it is with all bodies whatever, as will be explained shortly. In some cases, however, compounds may be mechanical as well as chemical, and in others may have a mixed character; such is peculiarly the case with mixtures, and solutions in water and in alcohol; thus sulphuric acid and water may be united in any proportions, and although water will take up only a certain quantity of any salt, yet more water may afterwards be added to any extent, without altering the character of the solution, merely diluting it. Thus it is with a solution of resin and spirits of wine, more spirit *ad infinitum* might be added without change of chemical properties. The same is the case with the combinations of the metals with each other, called alloys and amalgams. It will be most convenient therefore to consider these before proceeding to the laws of chemical union and affinity.

ALLOYS AND AMALGAMS.

Metals when fused together always retain their metallic appearance and character, but alter each other materially in fusibility, color, degree of hardness, density, solubility, and other properties; thus, alloys are justly considered chemical compounds; yet, whether metals combine in exact relative proportions is a matter of doubt. The following is a synopsis of the chief alloys, as well as of the arts of precipitating metals upon others:—Gilding, silvering, &c.,—the first do not admit of explanation, the latter are explained briefly. The figures in the experiments which follow, show the proportional weight of each particular metal, used in forming the alloy. They are in the case of alloys to be melted together. The more infusible metal to be melted first, and the others added. Thus, in making brass of copper and zinc, if zinc be first put in, and then the copper added, or if they be put in together, the zinc would melt, burn, and fly off in fumes before the crucible had attained a heat sufficient to melt the copper. Also, be it observed, that previous to pouring an alloy into a mould of any kind, it should be stirred up with a *piece of wood*, and in the act of pouring a *birch* stick is inserted into the melted metal, so as to hold back the dross or oxyde upon the surface. This may appear unimportant, but it is in reality of most essential use, and for this chemical reason. The crucible being taken from the fire, of course exposes the fused metal to contact with the air, and oxidation at that high temperature rapidly ensues. Were the partially oxidated metal allowed to enter the mould, the cast would be necessarily imperfect; to prevent this, the stick of green wood is used, and its action, not I believe hitherto explained in chemical books, appears as follows:—The wood immersed in the melted metal becomes hot, chars and burns, during which changes in the wood, it combines with the oxyde. First, pyroligneous acid is given off — this takes up the oxyde as soon as formed, and not only so, but the charred and burning portion of the wood absorbs the oxygen of the surrounding air, forming with it carbonic acid, and thus in a great degree keeps the metal from contact with the atmosphere, which is the source of contamination.

The following shows the furnace as usually constructed for the brass founder, the principle of it is applicable to the melting of metals in general, unless they are of a very refractory nature, as if so the reverberatory furnace previously described must be resorted

to. The cut on the preceding page is supposed to be a side section of the *air* furnace. The fuel is put in at the top of A, which is the body of the furnace. The iron plate C which covers it being removed for that purpose. A, the crucible, is also inserted into the fire, and taken out again by this orifice. B is the ash hole, which is open to the apartment that there may be the requisite supply of air to the fire. D is a damper which crosses the chimney to regulate the combustion. The upper part of the furnace C is usually even with the floor of the casting room, the ash-hole, &c., being beneath.

ALLOYS.

Ex. 535. 1 part potassium, 3 sodium. This is the most fusible of all alloys, remaining fluid at 32° Fahr.

536. 1 potassium, 3 sodium. This alloy is brittle and crystallizable at ordinary temperatures,—a remarkable circumstance, for the metals are not so; and as is seen by the last experiment, other proportions of them occasion a greater fluidity than either possesses alone.

537. *Alloy of zinc and iron.*—Into a ladle or crucible containing zinc, at nearly a red heat, drop some red hot iron nails or wire; they will unite and form a white, brittle alloy.

538. *Meteoric iron. Nickle and iron.*—This substance may be imitated by fusing together iron and nickle. In natural meteoric stones, these metals exist in various proportions, 3 or 4 per cent. of nickle is sufficient. With this proportion of ingredients, the alloy is malleable and whiter than pure iron. With $\frac{1}{10}$ of nickle added, iron loses its malleability, and becomes yellowish.

539. *Pakfong, Tombac, and Chinese white copper.*—"40·4 parts of copper, 31·6 nickle, 25·4 zinc, and 2·6 iron. This alloy is white and hard."—*Dr. Fyfe.*

540. *German silver, first receipt.*—"1 part nickle, 1 zinc, 2 copper; or when intended for rolling 25 nickle, 20 zinc, 60 copper, to which, if for casting 3 of lead may be added."—*Gersdorff. Quart. Jour.*

541. *Ditto, second receipt.*—8 copper, 2 nickle, 3½ zinc. This is the commonest article of the kind that can be made.

542. *Ditto, third receipt. (Electrum.)*—the last add 1 part more nickle. This is a better admixture, and it becomes a superior article by a still larger admixture of the nickle, until this metal is added to the amount of ¾ the weight of the copper. Where more than 3 parts nickle are used to 8 of copper, the alloy is called *electrum.*

543. *Tutenag.*—8 copper, 3 nickle, 6½ zinc. This alloy is very fusible, but very hard, and not easily rolled. It is best adapted for casting.

544. *Tombac of Europe, or red brass.*—From 8 to 10 parts copper to 1 of zinc.

545. *Fine brass.*—2 parts copper to 1 zinc.

546. *Manheim gold.*—3 parts copper to 1 zinc and a small quantity of tin; this is the best imitation of gold, for jewellery, &c.

547. *Common brass.*—16 copper, 9 zinc.

548. *Plating brass.*—8 parts fine brass and 5 zinc.

549. *Dutch leaf, or foil.*—11 parts copper, and 2 zinc.

550. *Prince's metal.*—3 copper and 1 zinc.

551. *Pinchbeck.*—5 copper and 1 zinc.

552. *Bell metal.*—3 to 5 parts copper to 1 tin; a little zinc is added for small bells, and a less proportion of tin for very large ones. This alloy is sonorous, of a whitish color, and of a greater specific gravity than the average of its constituent metals.

553. *Bath metal.*—32 brass and 9 zinc.

554. *Mosaic gold.*—100 copper and from 52 to 55 of zinc.

555. *Similor or Petit-or.*—4 copper and 1 zinc.

556. *Bronze.*—7 copper, 3 zinc, 2 tin or copper, with $\frac{1}{10}$ of tin.

557. *Alloy of the standard measures used by government.*—"Mr. Bate, who had to manufacture these measures, used 576 parts by weight of copper, 59 of tin, and 48 of brass, as being equal to brass in hardness, worked with the same facility, and less liable than brass to oxidation."—*Brande.*

558. *Speculum metal.*—7 copper, 3 zinc, and 4 tin. Mr. Mudge used only copper and grain tin in the proportion of 2 pounds to 14 ounces and ½. Mr. Edwards recommends, ("Nich. Journal,") 6 copper, 2 tin, and 1 of arsenic. Mr. Little gives as the best composition, 32 parts of best bar copper, 4 of brass pin wire, 16½ of tin, and 1¼ of arsenic. For Lord Rosse's large speculum, (cast April 14th, 1842, and the largest ever made,) the composition used was 126 parts of copper and 57½ of tin.

559. *Hard solder.*—The same as fine brass, which see, *Ex.* 547.

560. *Alloy of copper with antimony.*—Equal parts of these metals form a very beautiful alloy, very hard, and of a fine violet color. It has not yet been applied to a useful purpose.

561. *Blanched copper.*—8 copper and $\frac{1}{2}$ arsenic.

562. *Tutania, or Britannia metal.*—4 brass and 4 tin ; when fused, add 4 bismuth and 4 antimony. This composition is added at discretion to melted tin.

563. *Second receipt.*—100 tin, 8 antimony, 2 bismuth, and 2 copper.

564. *German tutania.*—$\frac{1}{4}$ copper, 1 antimony, and 12 tin.

565. *Spanish tutania.*—8 ounces scrap iron or steel, 1 ℔ of antimony, and 3 ounces of nitre. The iron or steel must be heated to whiteness, and the antimony and nitre added by degrees. 2 ounces is added to every pound of tin required for the manufacture.

566. *Plummer's solder.*—Equal parts of lead and tin.

567. *Tinman's solder.*—2 lead and 1 tin.

568. *Soft or pewterer's solder.*—2 tin and 1 lead.

569. *Common pewter.*—4 tin to 1 lead.

570. *Best pewter.*—100 tin, 17 antimony.

571.—*Hard pewter, pot metal.*—12 tin, 1 antimony, and 4 copper.

572. *Metal for music plates, and for flute key valves.*—2 lead and 1 antimony.

573. *Metal for printer's types.*—5 lead and $\frac{1}{4}$ antimony. The antimony gives a hardness to the lead, without which the type would speedily be rendered useless in the printing press.

574. *Metal for small types and stereotype casting.*—9 lead, 2 antimony, and 1 bismuth. This alloy expands in cooling ; the mould is therefore entirely filled when the metal is cold, and no blemish is found in the letters.

575. *Queen's metal.*—9 tin, 1 antimony, 1 bismuth, and 1 lead, or 100 tin, 8 antimony, 1 bismuth, and 4 copper. This composition is used for tea-pots and other vessels, intended to imitate silver.

576. *White metal,*—10 lead, 6 bismuth, $\frac{1}{2}$ antimony, or 2 lb. antimony, 8 ounces brass, and 10 ounces tin.

577. *Mock platinum.*—8 brass and 5 zinc.

578. *Silver coin of Britain.*—11$\frac{1}{10}$ of pure silver and $\frac{9}{10}$ copper ; a lb. troy therefore is composed of 11 ounces, 2 dwts. of pure silver, and 18 dwts of copper. It is coined in to 66 shillings.

579. *Silver solder for jewellers.*—19 fine silver, 1 copper, and 10 parts brass.

580. *Silver solder for plating.*—1 brass and 2 silver.

581. *Solder for steel joints.*—19 fine silver, 1 copper and 2 brass.

582. *Gold coin of Britain.*—11 parts gold and 1 copper : 20 troy lbs. are coined into 934 sovereigns and 1 half sovereign. 1 lb. was formerly coined into 44$\frac{1}{2}$ guineas ; it now produces 46$\frac{29}{40}$ sovereigns. Previous to 1826, silver formed part of the alloy of gold coin ; hence the different color of our gold money.

583. *Union of gold with antimony, &c.*—Most metals united to gold render it extremely brittle, [though they may be in extremely small quantity. This is especially the case with antimony, lead and bismuth, so that even the fumes of these metals will unite with gold in a melted state, and completely destroy its tenacity and malleability.

584. *Gold solder.*—12 gold, 2 silver, and 4 copper.

585. *Ring gold.*—6 dwts. 12 grains pure copper, 3 dwts. 16 grains fine silver, and 1 ounce 5 dwts. pure gold.

586. *Jeweller's gold* is made of variable proportions of gold and copper, sometimes of gold and silver.

587. *Alloy of gold with platinum.*—15 parts gold and 1 platinum. The gold must be melted before the platinum is added. This alloy is whiter than gold. Platinum has the singular property of depriving gold of its peculiar color ; if 10 parts of gold are united to only 1 of platinum, the alloy will appear quite white. There is another remarkable property attending this alloy of gold and platinum, that it is soluble in nitric acid, which does not act upon either of the metals in a separate state.

588. *Union of platinum with other metals.*—If a small piece of tin, zinc, or antimony, be rolled up in platinum leaf, and exposed to the jet of a blow-pipe, the two metals combine with such energy, when nearly white hot, as to produce a kind of explosion.

589. *Mock gold.*—"Fuse together 16 copper, 7 platinum, and 1 zinc; this alloy much resembles gold."—*Cooper.*

590. *Second receipt.*—"16 platinum, 7 copper, and 1 zinc. This also is of a fine gold color."—*Hermstadt.*

591. *Alloy of steel and platinum.*—Platinum, although the most infusible of metals, when in contact with steel melts at a comparatively low temperature, and combines with it in any proportion. This alloy does not rust or tarnish by exposure to a moist atmosphere for many months. The alloy is malleable, and well adapted for instruments which would be injured by slight oxidation, as mirrors for dentists, &c. The best proportions do not yet appear to be known ; but it appears that if much platinum be used, the alloy has a damask or wavy appearance. Steel for cutting instruments is much improved by even $\frac{1}{500}$th of platinum.

592. *Alloy of steel and silver.*—Steel 500 parts, and silver 1 part. If a larger proportion of silver is employed, the compound appears to be a mechanical mixture only, the silver is distinctly seen in fibres mixed with the steel, and the alloy is subject to voltaic action. When the proportion does not exceed $\frac{1}{500}$, the compound appears to be a chemical union; the steel is rendered much harder, forges remarkably well, and is infinitely superior to the best cast steel for cutting instruments, &c.

593. *Alloy of steel with rhodium.*—If from 1 to 2 per cent. of rhodium be combined with steel, the alloy possesses great hardness, with sufficient tenacity to prevent cracking, either in forging or hardening. This alloy requires to be heated to about 73° Fahr. above the best English cast steel in tempering. It is superior to that metal; but the scarcity of rhodium will prevent the extensive use of this valuable compound.

594. *Wootz, or alloy of steel and aluminum.*—Pure steel in small pieces was heated intensely for a long time, and formed a highly crystalline carburet. This being broken, and rubbed to powder in a mortar, was mixed with pure alumina, and the whole intensely heated in a close crucible for a considerable time. The result was a brittle alloy, of a white color, and close granular texture. When 700 grains of good steel and 40 of this alloy were fused together they yielded a good malleable button, which being forged into a bar and polished, gave by the application of diluted sulphuric acid the beautiful damask which is peculiar to wootz, and which wootz retains even after repeated fusions.

595. *Fusible alloys: first.*—Melt together 1 ounce each of zinc, bismuth, and lead. This alloy is so fusible that it may be melted in moderately hot water.

596. *Second: Sir Isaac Newton's alloy.*—8 parts bismuth, 5 lead, and 3 tin. Mould this alloy into bars, and take them to a silversmith's to be made into ½ a dozen tea spoons. If one of these be given to a stranger to stir his tea, as soon as it is poured from the tea pot, he will be not a little surprised to find the spoon melt in the tea cup. The effect is very peculiar, for bismuth does not melt till at the heat of 476°, lead at that of 612°, and tin at 442°; yet this alloy melts at the heat of boiling water, or 212°.

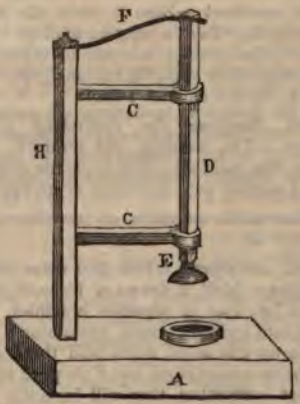
597. *Third receipt.*—14 bismuth, 16 mercury, and 32 lead.

598. *Fourth receipt.*—4 bismuth, 4 lead, 1 tin, and 1 mercury.

599. *Fifth receipt.*—2 lead and 1 bismuth.

600. *Sixth receipt.*—3 bismuth, 6 lead, and 3 antimony.

601. *Napoleon, or En cliché medals.*—These are made of the above-mentioned alloys, that given as Newton's alloy, and which is called in France, owing to its principal use, D'Arcey's alloy, is most commonly employed. The Napoleon medals were made by the following process:—A press of the under-mentioned construction is first prepared. A is a heavy and solid stand, with an upright a foot or more in length, B. This supports two bent arms C C, which have a socket in each for the reception of the square rod D. The die is placed at E, being attached to the lower end of the square rod D. F is a spring to raise the rods while the metal is being poured in. In the centre of the stand, and immediately under the die, is a small metal box, exactly of the size that the medal is to be made. The melted alloy is poured into the box until full. It is then carefully observed, and when it begins to crystallize upon the surface, the die is let down upon it, by forcing down the rod D, with the hands applied to the upper part. In a few minutes it will be cold enough to remove, and will be found to bear a fine impression of the die.



602. *Moulds for electrotype depositions.*—These also are made of either of the fusible alloys, and without a press, as follows:—Pour the alloy upon a few sheets of brown paper, having made a slight depression in the paper that the metal may not run off. When on the point of setting, place the coin, &c. to be copied, previously made as hot as the hand can bear it, upon the alloy. Place the heel upon the coin, and rest the body upon the heel only; the weight, if the whole be done quickly, will occasion the coin partly to sink into the fused alloy, and a fine mould, of course the reverse of the coin, will be the consequence. It is advisable to draw a card across the top of the alloy, while yet fluid, to separate the oxyde which forms upon the

surface, otherwise this will be driven into the metal, and the mould be proportionably less perfect.

603. *Metallic pencils.*—2 bismuth, 5 lead, and 3 tin.

AMALGAMS.

Ex. 604. *Mercury and potassium, or sodium.*—To 70 parts of mercury, add 1 of potassium; they will unite, and form a *hard brittle* alloy, although the one metal is fluid, and the other of the consistency of wax. The same may be tried with sodium. See also *Ex.* 423.

605. *Second method.*—Add a little liquid mercury to the liquid alloy of potassium and sodium, of *Ex.* 536. The mixture will instantly become solid, and heat will be generated sufficient to inflame the alloy.

606. *Amalgam for injecting anatomical preparations.*—Add the proportion of 2 parts mercury to the composition of Newton's fusible alloy. Another receipt is 2 parts mercury, 1 bismuth, and 1 lead.

607. *Amalgam for the cushions of electrical machines.*—Zinc 2 parts, tin 1, and mercury 5.—The tin may be omitted. Rub the cushion with a mixture of tallow and bees' wax before applying the amalgam, which may be spread on with a knife.

608. *Amalgam for varnishing plaster figures.*—Tin, mercury, and bismuth, equal parts, fuse and cool; then make the amalgam into a varnish with the white of an egg.

Mineral marmoretum, or succedaneum.—See *Ex.* 66.

609. *Amalgams which fuse when rubbed together.*—Melt 2 drams of bismuth and 2 drams of lead in separate crucibles, pour them into separate vessels, containing a dram of mercury in each, when cold these alloys will be in a solid state, but if they are rubbed against each other, they will instantly enter into fusion.

610. *Amalgam for lining glass globes.*—For this purpose, 1 part of mercury and 4 of tin have been used; but if 2 parts of mercury, 1 of tin, 1 of lead, and 1 of bismuth are melted together, the alloy which they form, will answer the purpose better.

611. *Amalgam of gold or silver.*—Place a gold leaf in the palm of the hand, and pour upon it a globule of mercury. The latter will be seen to absorb, or combine with the gold; forming a more or less fluid and yellow amalgam, according to the proportion of the two metals. This amalgam is used in water gilding. The affinity of mercury for gold and silver is so strong, that those who are foolish enough to clean their watch cases with mercury, or one of its salts will find them irretrievably spoiled; the same holds good with plated articles cleaned by a vile composition, sold about the streets for this purpose, made of the nitrate of mercury, ground up with whitening. Even those who are obliged to take calomel, and other mercurial medicines, should abstain from wearing any gold articles, or carrying gold money, as the mercury oozes through the pores of the skin, and attaches itself to the gold money carried in the pocket, rendering it so brittle, that it may often when thus contaminated be broken in two. The best way of restoring money thus spoiled is to keep it red hot for an hour or so, in the bole of a tobacco-pipe, a crucible, or ladle.

612. *Preparation of ditto, practised by water gilders.*—Put 2 drams of mercury into a crucible, and heat it until vapor is seen to issue from it; now throw into the crucible 1 dram of gold or silver, and stir them with an iron rod. When the gold or silver is found to be fused, or incorporated with the mercury, the amalgam is to be poured into cold water; when cold, pour off the water, and collect the amalgam, which will be of about the consistence of soft butter. This after having been bruised in a mortar, or shaken in a strong phial, with repeated portions of salt and water, till the water ceases to be fouled by it, is fit for use, and may be kept for any length of time without injury in a stopped phial. It is essential in this manufacture, that the mercury should be extremely pure, as the least admixture of lead, tin, or metal, would materially injure the gilding for which it is used.

PRECIPITATION OF METALS.

The precipitation of metals includes a great portion of the arts of gilding, plating, tinning, &c. All of this which is of a chemical character, is given beneath; it will be seen that numerous metals unite, in consequence of their mutual affinity for each other, either at ordinary or increased temperatures. In other instances a different method must be adopted, and their union accomplished by chemical decomposition; one metal having power to decompose the salts of another, and consequently leaving that other in a metallic state. These are examples of *elective* affinity—a term used by the chemist to signify the apparent preference, or rather the greater aptitude of some bodies to unite than others.

Ex. 613. *To coat tin with bismuth.*—Dissolve 10 grains of nitrate of bismuth in a wine glass of distilled water, and add 2 drops of nitric acid. Stir the whole with a glass rod, and then immerse a rod or plate of tin. The bismuth will immediately begin to be precipitated on it in very small shining plates. The reason is, that nitric acid having a stronger affinity for tin than for bismuth, attacks the former metal, and deposits the latter in its metallic state.

614. *Tinning iron plates.*—Clean with coal ashes a slip of sheet iron, and put it in a vessel containing a quart of water and a dram of sulphuric acid. Let it remain in this *pickle*, as it is called, for 24 hours; then take it out, dry it well, grease it with a piece of tallow, and put it in a hot place. Now melt an ounce of tin in a crucible or ladle, and dip the clean slip, whilst *hot*, in it, taking care that the tin shall cover every part, when it will be completely united to the iron, forming a coat of tin, and penetrating into the substance of the iron, so that when cut with scissars the whole presents a silvery lustre. Thin sheets of iron tinned in this manner are called *tin plates*, and well known for the making of saucepans and other tin ware. This experiment shows the union of two metals when brought to a certain temperature. The object of the tallow is to prevent oxidation, so that the surface of each metal continues bright and clean, and does not become affected by contact with the air, which it rapidly does at the temperature to which it is raised without this precaution.

Tinning pins and tacks. Ex. 138.

615. *Tinning copper vessels.*—Clean a slip of copper from all impurities; rub it over with a solution of chloride of ammonia, (sal ammoniac.) Then heat the slip, and immediately rub it over with tallow or pitch—now heat it again, and rub it over with a piece of tin. This metal will immediately combine with the surface, giving it a silvery coat. The mixture used for the tinning of copper vessels consists of 3 lbs. of lead and 5 lbs. of pewter. Those covered with the above composition soil the fingers when rubbed upon them; pure tin does not occasion a stain.

616. *Coating iron with zinc.*—The iron is made quite bright, then rubbed with, or soaked in a solution of chloride of ammonia, thoroughly to clean the surface, then the iron is dipped into an iron pot, full of melted zinc; and upon being taken out the zinc is found to cover the surface of the iron. If a thicker coat of zinc is wanted it may be obtained by dipping the article a second time.

617. *Water gilding.*—Immerse a very bright piece of copper in a diluted solution of nitrate of mercury. By the superior affinity of copper for nitric acid, the mercury will be precipitated; now spread the amalgam of gold (*Ex.*611.) rather thinly over the coat of mercury just given to the copper. This coat unites with the amalgam, but of course will remain on the copper. Now place the piece or pieces so operated on in a clean oven or furnace, where there is no smoke. If the heat be a little greater than 660°, the mercury of the amalgam will be volatilized, and the copper will be beautifully gilt. In the large way of gilding the furnaces are so contrived, that the volatilized mercury is again condensed, and preserved for future use, so that there is no loss in the operation. In performing this experiment it is advisable to keep out of the fumes of the mercury.

618. *Gilding iron through the medium of a coat of copper.*—This mode of giving a gold coat to iron is certainly very ingenious, as it comprehends several processes and affinities. The iron bar, instrument, or vessel, is first made perfectly bright, then soaked in an acidulated liquor, and afterwards rubbed dry with whitening. Now prepare a solution of the sulphate of copper, and immerse the iron in it; in a few seconds the whole will become covered with a very beautiful but thin coat of copper, so as to appear entirely composed of that metal. The amalgam of gold is now to be applied, as in the last experiment, and put into the furnace for the separation of the mercury.

619. *Gilding by the ethereal solution of gold.*—Pour some of the ethereal solution of gold into a wine glass, and dip therein the blade of a new pen-knife, lancet, or razor; withdraw the instrument, and allow the ether to evaporate. The blade will be found to be covered by a very beautiful coat of gold. A clean rag, or small piece of sponge, may be dipped in the ether, and used to moisten the blade, with the same result. This coating of gold will remain upon the steel for a length of time, and will preserve it from rusting.

620. *Ornamental gilding on cutlery.*—Swords, knives, and other bright steel goods, may be ornamented with gold flower, letters, or other devices, by drawing or writing upon them with a camel's-hair pencil, dipped in the ethereal solution of gold, burnishing afterwards, when the ether has evaporated, with a piece of wash leather.

Precipitation of gold and silver by hydrogen gas. See *Ex.* 251, 252, and 253.

621. *Precipitation from phosphoric ether.*—Immerse a white silk or satin ribbon in phosphoric ether, (prepared by *Ex.* 391.) When the ether has evaporated, which will be known by the smoking of the phosphorus on the ribbon, immerse it in a wine glass containing a solution of nitro-chloride of gold. The gold will be instantly reduced to the metallic state all over the silk.

Reduction of gold and silver by sulphurous acid gas, phosphuretted hydrogen, &c. See these gases.

622. *Plating looking glasses.*—This art is erroneously called silvering; for as will be presently seen there is not a particle of silver present in the whole composition. On tin foil, fitly disposed on a flat table, mercury is to be poured, and gently rubbed with a hare's foot, a piece of wadding, or other soft substance. It soon unites itself to the tin, which then becomes very splendid, or as the workmen say, *quickened*. A plate of glass is then cautiously to be slid upon the tin leaf, in such a manner as to sweep off the redundant mercury, which is not incorporated with the tin. Leaden weights are then to be placed on the glass, and in a little time the quicksilvered tin foil adheres so firmly to the glass, that the weights may be removed without any danger of its falling off; the glass thus coated is the common looking glass. About 2 ounces of mercury are sufficient for covering 3 square feet of glass.

623. *Silvering the internal surface of glass globes, &c.*—Take some of the amalgam made by *Ex.* 610.—Warm the glass vessel, and pour the amalgam into it. Then turn the vessel about until the amalgam adheres to every part of the internal surface, rendering it as brilliant as a looking glass.

Silvering clock faces, &c. *Ex.* 132.
Silvering Daguerrotype plates. *Ex.* 133.
Silvering ivory. *Ex.* 134.
Platinizing brass, &c. *Ex.* 136.
Covering iron with tellurium. *Ex.* 135.
Plating zinc with copper. *Ex.* 122.

624. *Precipitation of mercury on zinc.*—Rub a plate of zinc made bright with the nitrate of mercury, the zinc will unite with the acid, and leave the mercury to deposit itself as a coat upon the surface. In this manner zinc plates are amalgamated for galvanic batteries.

625. *Oil gilding.*—The wood or other body to be gilt, having been painted with ordinary oil colors, and afterwards dried and smoothed, has the ornaments, letters, &c., which are to be gilt upon it, painted in gold size—a thick quickly-drying varnish prepared for the purpose. When this has become very nearly dry, so that it merely feels *tacky* or glutinous to the fingers, gold leaf is applied to the surface. This adheres to the gold size, while the superfluous portions around the edges of the letters, &c., are wiped off with a piece of wool or cotton wadding.

626. *Gilding picture frames, &c.*—The surface to be gilt must be carefully covered with a strong size, made by boiling down pieces of white leather or clippings of parchment, till they are reduced to a strong jelly. This coating being dried, eight or ten more must be applied—the size being mixed with a small quantity of whitening. The last coat is composed of size and massicot, (the yellow oxyde of lead,) or sometimes yellow ochre. While this last is yet moist, the gold leaf is put on. It will immediately adhere, and when dry those parts which are intended to be most brilliant are to be carefully burnished by an agate or a dog's tooth, fixed in a handle.

627. *Gilding letters on manuscripts, &c.*—The gold powder, prepared by *Ex.* 519, is mixed with a little weak gum water, and the letters written with it, or else a glutinous ink may be used, and gold leaf applied to the ink before it is quite dry; or still better, suffer the ink to dry, and then breathing upon it, will render it sufficiently moist for the gold leaf to adhere to it.

628. *Gilding paper, the edges of books, &c.*—The edges being cut are washed over with a composition of 4 parts Armenian bole and 1 of candied sugar, ground together with water to a proper consistence. To this add the white of eggs, in quantity about half that of the water; beat the whole together, and lay it on with a brush, and when nearly dry burnish the surface. Then slightly moisten it with a sponge, dipped in water, and apply the gold leaf with a piece of cotton wool. When dry, burnish, interposing a piece of very thin paper between the gold and the burnisher.

629. *Lettering the backs of books.*—Stamps of the letters or devices being prepared, they are laid close to a clear fire, and made pretty hot, but not red hot. The back of the book is dusted over with finely powdered rosin or mastic; lay a piece of gold leaf, of sufficient size, on the place intended for the letter, and press the hot tool upon it; the heat will, of course, melt the rosin, and occasion the gold leaf to adhere firmly to the leather, while the superfluous edges are wiped off with a slightly greasy cloth.

630. *Gilding glass and porcelain.*—This is done by painting the part to be gilt with an adhesive varnish of boiled linseed oil, in which has been dissolved a little copal or amber; this is tempered for working with spirits of turpentine. Let this varnish become quite dry, and then place the article in an oven, till it becomes so hot as almost to burn the fingers. At this temperature the varnish will become adhesive, and a piece of gold leaf applied in the usual way will immediately stick; it may be burnished when cold.

631. *Second method.*—Mix gold powder with borax and water; then paint the lines and ornaments with it. When quite dry, the glass is to be put into a stove, heated to a high temperature. The borax by vitrifying cements the gold with great firmness to the glass, and is a method far preferable to the former.

THE ATOMIC THEORY, CHEMICAL SYMBOLS, &c.

It was long maintained that the particles of matter were infinitely divisable, and that we could never ascertain their ultimate size or weight. It is now thought that the atoms of all bodies are of a determinate relative weight and volume; although our sight assisted by the finest glasses may not be sufficient to distinguish each individual atom, nor yet to ascertain its positive proportions and gravity. Late discoveries and modes of reasoning leave scarcely a doubt that such is the case.

Equally apparent, and it may be said certain is the fact, that they unite together only in certain degrees, or proportions. For example, oxygen unites with nitrogen, in five different ways, and according to the number of atoms of each, so is the character of the compound. One atom of oxygen, and 1 of nitrogen, form nitrous oxyde, or the *laughing gas*. The same nitrogen with 2 atoms of oxygen form another gas called nitric oxyde; another atom of oxygen would make it hypo-nitrous oxyde; 4 atoms of oxygen and 1 of nitrogen form nitrous acid, and 5 atoms of oxygen with the same, nitric acid. Thus nitrogen unites with 1, 2, 3, 4 and 5 atoms of oxygen, but with no other number. Next, we will assume that these atoms have certain relative weights; oxygen we will take as 8, and nitrogen as 14. Three of the above compounds of oxygen and nitrogen will therefore be as follows:—

Nitrous oxyde.............. $1\,O+1\,N=8+14=22$
Nitrous acid................ $4\,O+1\,N=32+14=46$
Nitric acid.................. $5\,O+1\,N=40+14=54$

The numbers 22, 46, and 54, therefore, represent the three compound bodies, and are called chemical *equivalents*, they being each equivalent to the aggregate of the whole atoms, and remembering that there is only one atom of one of the bodies; the number of atoms of the other is of course immediately found.

Bodies compounded of compounds follow the same rule: thus sulphuric acid consists of 1 atom of sulphur and 3 of oxygen; and as sulphur is number 16—the proportional for this acid would be 40, or $16+24$. Potass consists of potassium 1, and oxygen 1 atom, or 40 (The number of potassium) $+8=48$. Unite this acid and alkali, 1 atom of each together, and the result is the sulphate of potass; the atomic weight or equivalent number of which is $40+48=88$. Supposing nitric acid be used, the atomic weight of which is 54; the compound produced, the nitrate of potass, would have the atomic weight of $54\times48=102$, by which it is to be understood that 54 grains, ounces, pounds, &c. of nitric acid, will combine with as much potass as 40 grains, ounces, pounds, &c. of sulphuric acid; and thus as the rule is general, we are taught the *exact* quantity of a chemical substance, which is required for any operation, whether of composition or of decomposition; and, by knowing the atomic weights of the elements, we learn the nature of all their combinations, and an ordinary number answers the purpose of much explanation.

Time and space in chemical works is saved by adopting a set of *symbols* for the substances in ordinary use, such as O for oxygen, and S for sulphur. In the nature of these characters, chemists have much disagreed, many of them adopting a series for their own use. The simplest, and those most easily understood and remembered, are, where the initial letter of either the Latin or the English name of the substance is used to designate that substance. The following list of the elements, and some common compounds symbols, and atomic weights, will materially assist and shorten our future explanations.

SYMBOLS AND ATOMIC WEIGHTS OF THE PRINCIPAL ELEMENTS, &c.

Name.	Sym.	Equi.	Name	Sym.	Equi.	Name.	Sym.	Equi.
Oxygen	O	8	Iron	Fe.	28	Lime	Cal. O	28
Hydrogen	H	1	Zinc	Z	33	Alumina	Al. O	18
Chlorine	Cl.	36	Tin	Sn.	58	Potass	P. O	48
Iodine	I.	125	Cobalt	Cob.	30	Soda	So. O	32
Carbon	C	6	Nickle	Nic.	28	Magnesia	Mg. O	20
Sulphur	S	16	Copper	Cu.	32	Barytes	Ba. O	78
Phosphorus	Ph.	12	Lead	Pl.	104	Sulphuric acid,	S. O 3	40
Potassium	P	40	Antimony	An.	65	Hydrochloric acid	Cl. H	37
Sodium	So.	24	Bismuth	Bi.	72	Nitric acid	N. O 5	54
Calcium	Cal.	20	Arsenic	Ar.	38	Carbonic acid	C. O 2	22
Barium	Ba.	69	Mercury	Hg.	200	Ammonia	N. N 3	17
Strontium	St.	44	Silver	Ag.	108	Acetic acid	C 4.H 3. O 3	51
Magnesium	Mg.	12	Gold	Au.	200			
Manganese	Mn.	28	Platinum	Pl.	96			

It is advisable for the young chemist to learn the above table so as to remember it perfectly, as by its use an absolute certainty will be given to all his operations; the intended effect will not only be insured, but with such economy, that not a grain of any thing whatever will be lost or misapplied. Without this table, supposing it be desired to make bluestone, which is the sulphate of copper, we should naturally wish to know how much of each substance,—that is, of copper and of sulphuric acid is to be used. The table will give us the information, for it says, that 40 of sulphuric acid is equal to 32 of copper. We may not however wish to use exactly 32 grains, pounds, &c. of copper, but rather 100 grains of copper. A common rule of three equation will give the exact quantity of acid required, as follows:—If 32 copper : 40 acid : : 100 copper : Ans. 125 grains of acid required. Again, suppose we desire to decompose the sulphate of copper by means of iron filings, (see *Ex.* 120,) How much are we to use for the exact purpose? Answer, 87½ grains of iron; for, if 32 copper : 28 iron :: 100 copper : 87½ iron. But we may wish to throw down the copper by potass. If so, we must use 150 grains, which number is obtained by a similar equation. We may repeat these experiments without end, with the same exact result; not however to dwell further upon it, numberless examples of which will be given hereafter, we will merely explain two or three formulæ, connected with the subject, and similar to which others will repeatedly occur.

Chemical compounds, which consist of two elements only, are called ***binary.*** Those of three elements are *ternary*, and those of four, *quaternary*. Even these are often united together, forming substances still more compound. The following are examples of each.

Water is binary, consisting of hydrogen 1 atom, and oxygen 1 atom. As the number 1 need not be expressed, the symbol of water would be $H + O$ or $H.\,O$.

Gum is a ternary compound, consisting of oxygen 6 atoms, hydrogen 6, and carbon 7 atoms. Its symbol would be therefore $O\,6 + H\,6 + C\,7$, or $O\,6.\,H\,6.\,C\,7$; but equal numbers of the atoms of oxygen and hydrogen constitute water, and if we take W as a symbol for water, we shall have the symbol of gum $W + C\,1\tfrac{1}{6}$, or we may have $O + H + C\,1\tfrac{1}{6}$.

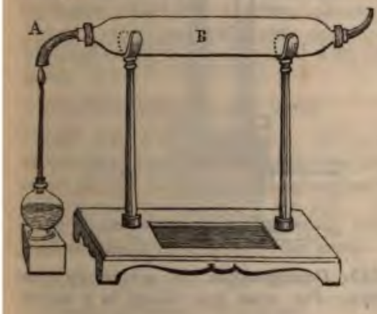
The oxyde of silver is binary, the symbol being $Ag + O$, or $Ag.\,O$. Nitric acid is also binary, and its symbol, as before given, is $N + O\,5$, or $N.\,O\,5$. Unite these binaries together, the result is the salt called lunar caustic, or the nitrate of silver; its symbol would therefore be $Ag + O + N + O\,5$. Although the above symbol would according to the preceding examples be correct, yet on account of the character + occurring so many times confusion is likely to ensue; it is better therefore in the case of the simpler compounds to omit the +, and substitute a dot; this renders the whole clear and intelligible. It would alter the above symbol for the nitrate of silver into $Ag.\,O + N.\,O\,5$.

NEUTRAL OXYDES.

These are binary compounds of oxygen and some base, metallic or non-metallic; and in most cases consist of 1 atom of each element. Among the metallic oxydes are many of those beautiful powders used as pigments, the manufacture of which constitutes a branch of considerable trade. Among the non-metallic elements are some well known substances of first importance and interest. We shall consider them in the order of the elements already described, observing that where there are two neutral oxydes of a substance, that which contains the least quantity of oxygen is called the protoxyde, and that which contains the greatest quantity the peroxyde. When there are more than two, that which contains only 1 atom of oxygen is called the protoxyde, as before; if there should be one with an atom and a half of oxygen it would be called a sesquioxyde; if of two proportions a deutoxyde, or three proportions a teroxyde; and the highest degree of oxidation is always a peroxyde, whatever may be the proportion of oxygen; thus the deutoxyde or teroxyde may be also the protoxyde.

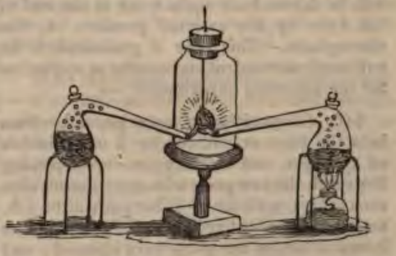
632. *Oxygen and hydrogen*, (H.O. = 9.) *Water, or protoxyde of hydrogen.*—To unite oxygen and hydrogen chemically we must apply either caloric or electricity. Ordinary flame of lamps, candles, &c., consists of hydrogen, mixed with carbon. The carbon unites with the oxygen of the air, burns, and flies off as carbonic acid gas. The hydrogen also burns, and uniting itself with the oxygen of the air also flies off in the state of steam; the union of the two forming water. This is very evident in cold weather on the windows of shops where gas is burned, the moisture depositing upon the inner surface of the glass. Cutlers and others, who burn a gas but little carburetted, have too much reason to lament the deposition of water thus formed upon their cold and bright iron and steel goods.

633. Burn a current of hydrogen under the copper tube A of the following cut; by uniting with the oxygen of the atmosphere, it will produce aqueous vapor, which passing into the glass cylinder B, will condense in drops. On examining the water thus produced, it is generally slightly acid from the presence of nitric acid, derived from the nitrogen of the atmosphere; if hydrogen be in excess, it sometimes contains ammonia.



634. Mix together 2 volumns of pure hydrogen and 1 of pure oxygen in a bladder; from this bladder fill a phial under water. When the phial is full of the mixed gases, suspend in it a piece of spongy platinum, fastened to a wire. The effect will be that the gases will heat the platinum, and that when heated will inflame the gases; they will go off with a loud explosion, and most probably burst the phial. The platinum should be made red hot some little time previously, to ensure its being perfectly dry.

635. Arrange some apparatus as in the following diagram:—Put into one retort some chlorate of potass, and apply heat beneath; oxygen will soon rise from the beak of the retort into the centre vessel. Into the other retort put the ingredients for making hydrogen, (*Ex.* 245.) Tie some spongy platinum to a wire of the same metal, several times coiled round it, heat this red hot, and immerse it in the mixed gases, so that hydrogen shall blow upon it on the one side, and oxygen on the other; an explosion will first ensue, after which the gases will burn more quietly; the platinum will glow with the intensity of the heat, and water be formed; as will be evident, by its being deposited on the inner surface of any cold vessel held over the ignited gas.



636. *Tendency of oxygen and hydrogen to unite mechanically.*—Fill a bottle with oxygen, and put it on a tube, furnish it with a cork and a long tube running through it; to the upper end of the tube fasten by a second cork, a bottle of hydrogen with its mouth downwards. Notwithstanding their relative position, after a time they will be found united together, half of the hydrogen having descended to the lower bottle, and half the oxygen ascended to supply its place. The mixture may be shown to have taken place by exploding the contents of the bottle.

637. Put a spoonful of water into a strong soda water bottle, fill it with hydrogen 2 parts, and oxygen 1 part, stand it upright on a table, and let drop cautiously into it a slip of potassium. When this touches the water it will burst into flame, and fire the mixed gases. It is advisable that the bottle should be wrapped in a cloth to prevent danger should the bottle burst, which is not unlikely.

638. *The mixed gases inflamed by electricity.*—Blow some soap bubbles with a mixture of oxygen and hydrogen contained in a bladder; when separated and flying upwards, communicate to them an electric spark, they will burst with a loud noise.

Hang to the ceiling a bladder filled with gases mixed together, pass an electric shock through it, and a deafening explosion will be the consequence.

639. *Increase of bulk when exploded.*—Procure a thick glass tube at least four feet long, furnished near one end with the proper detonating wires, and also with a stop cock to supply the gases—let there be also a plug or piston, capable of an easy motion up and down the tube, but yet so as to be air-tight; exhaust the tube of air, and pass into it 1 portion of oxygen and 2 of hydrogen. The moveable piston will rest close to the gases—these are to be detonated by the electrical spark, and at the moment of detonation the piston will be driven along the tube about 15 times as distant from the closed end as at first, making allowance for friction, arising from the weight of the piston and its rubbing against the tube. The next instant, as the gases are condensed into water, the piston will be driven back again quite to the end of the tube by the external pressure of the atmosphere.—This tube if graduated is an extremely convenient eudiometer or apparatus for the following experiments :—

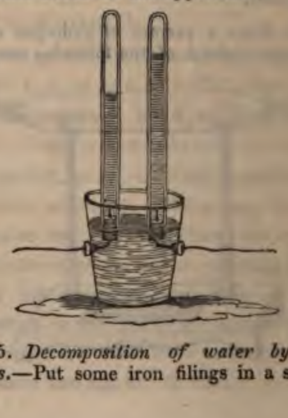
640. *Composition of water proved.*—Pass into the tube or eudiometer 2 cubic inches of hydrogen and 1 of oxygen—upon passing the spark the two gases will exactly neutralize each other; no trace of either gas will be left, and the piston will return exactly to the place it was at before the gases were injected; and supposing the experiment repeated several times, so as to ascertain accurately the result, the quantity of water it will be found weighs precisely the same as the united weights of both portions of the gases.

641. *Hydrogen unites with oxygen only in a certain ratio.*—Pass into the tube 2 cubic inches of hydrogen and 2 of oxygen—upon making the explosion one portion of oxygen will be left, as will be seen by the position of the piston. To prove which, pass in 2 other volumes of hydrogen, and explode; they will unite, and the piston return to its first situation, showing that the whole has been condensed into water.

642. Pass as before 2 volumes of hydrogen, and 5 of atmospheric air—make the discharge, and explosion will take place, leaving 4 measures of gas unconsumed; which, upon testing properly, will be found to be wholly nitrogen, arising thus: the atmospheric air contains one-fifth oxygen, and four-fifths nitrogen in its composition—the 1 part oxygen, leaves it to unite with the 2 parts of hydrogen to form water, leaving the nitrogen free.

643. *Power of combination limited.*—Mix in the tube, as before, 1 portion of hydrogen with 12 of air, or else with 15 of oxygen, and although the spark be passed through the mixture, no explosion will ensue—so also if the quantity of hydrogen be increased to 11 to 1 of the oxygen, or if the mixture be in relative and proper proportions, yet if expanded to 6 times its volume by heat, or 16 times its volume by the air-pump, no explosion will take place.

644. *Decomposition of water by galvanism.* Let there be 2 platinum wires passed through the bottom or sides of a glass vessel, of the size and form of a tumbler; let the inner points of the wires be furnished with a cork each, fitting very loosely, and the outer ends capable of extending to the poles of a galvanic battery, or what is the same thing, let them be united to other wires of some kind reaching to the battery. Let there also be two equal-sized tubes closed at the top. Fill the glass with water, and also the tubes with water, place one over each cork, and its mouth being beneath the surface of the water in the glass, the tubes will remain full of water. Next connect the wires with the battery, and the water will be decomposed into its two constituent gases; oxygen will occupy one tube and hydrogen the other, as may be easily tried; the hydrogen being double in quantity to the oxygen. The cut will show the general form of the apparatus.



645. *Decomposition of water by iron filings.*—Put some iron filings in a saucer,

moisten them with water, and place a bell-glass over them. If in a few days the bell-glass be examined, it will be found to contain hydrogen gas. Here the iron has been rusted or oxidized by the oxygen of the water, and the hydrogen is set free.

Note.—The water which crystals and other substances contain, and the water added to various bodies to dissolve them, and thereby render them more susceptible of combination or other chemical action, is not usually considered in giving their composition, unless particular analysis is required, or unless the nature of the body is thereby altered. When water combined with it materially affects the body, or when it exists in a definite proportion, the body is called a *hydrate.*

Oxydes of chlorine.—These are all acid products. See *Acids.*

646. *Oxyde of iodine.*—Fasten a bladder of oxygen to the end of a copper tube, heated by two or three lamps beneath, or still better by a furnace. To the other end of the tube fasten a retort, furnished with a safety tube, and containing a little iodine; apply heat beneath, and press the oxygen through the heated tube on to the vapor of iodine, they will combine and form the oxyde required. It may be dissolved in water.

Oxyde of bromine. See *Acids.*

Oxydes of nitrogen. See *Acid and Gases.*

647. Atmospheric air is a mechanical combination of oxygen and nitrogen, in the proportion of about $\frac{1}{5}$ of the former gas to $\frac{4}{5}$ of the latter, mixed with a minute quantity of carbonic acid gas, and under certain circumstances slightly impregnated with other gases.

Oxydes of sulphur. See *Acids.*

648. *Oxyde of phosphorus.* ($\mathrm{Ph}\,3 + \mathrm{O} = 56$.)—This, which is a reddish powder, is the result of *Ex.* 393; or, when phosphorus is decomposed by light as in *Ex.* 397. Also when fused phosphorus is stirred up with a red hot wire as in *Ex.* 402. See *acids.*

Oxydes of carbon. See *Gases and Acids.*

Oxydes of boron. See *Acids.*

METALLIC NEUTRAL OXYDES.

Oxydes of potassium and sodium. See *Alkalies.*

Oxydes of calcium, barium, strontium, magnesium, and aluminum. See *Earths.*

Oxyde of silicium. See *Earths.*

649. *The neutral oxydes of manganese are three,* the protoxyde, the sesqui- or deutoxyde, and the peroxyde. The peroxyde exists abundantly in nature, and is called from its color the black oxyde of manganese. It consists of 1 atom of manganese and 2 of oxygen. Its symbol and atomic weight is therefore $\mathrm{Man} + \mathrm{O}\,2 = 44$.

650. *Protoxyde of manganese.* ($\mathrm{Man} + \mathrm{O} = 36$.)—A dingy green powder obtained by passing a current of hydrogen over the red hot peroxyde contained in an iron tube. The hydrogen uniting with oxygen of which it robs the peroxyde. This is the base of all the ordinary manganesian salts.

651. *Hydrated protoxyde of manganese,* which is the above chemically united with water, may be obtained from the chloride of manganese, by adding to it a solution of potass, a bulky white precipitate of the hydrated protoxyde falls. ($\mathrm{Man} + \mathrm{O} = \mathrm{W}.\ 24$ per cent.)

652. *Deut- or sesqui-oxyde of manganese.* ($\mathrm{Man} + \mathrm{O}\,1\frac{1}{2} = 40$.)—Expose the protoxyde to a red heat in an open vessel, when it absorbs oxygen and becomes the deutoxyde, which is a deep brown powder. Also, when the black or peroxyde has been used for the making of oxygen, (*Ex.* 205,) the deutoxyde is left in the retort.

653. *Hydrated deutoxyde of manganese.*—The white powder of *Ex.* 651 soon becomes brown by exposure to the air, when it is the hydrated deutoxyde. The oxydes of manganese are much used to communicate a red and blue or purple color to glass and porcelain. ($\mathrm{Man} + \mathrm{O}\,1\frac{1}{2} = \mathrm{W}\ 10$ per cent.)

654. Pound up some flint-glass in a mortar, and add to it a very minute quantity of the peroxyde of manganese, fuse them together by the aid of a blow-pipe, or in a crucible on the fire. The oxyde will communicate to the glass a most beautiful amethyst color.

655. Mix a minute quantity of the peroxyde of manganese with 5 times its weight of borax. With a brush lay this over an unbaked tile or tobacco-pipe, let it be baked in the usual manner in a kiln, when the manganese will stain the clay in the same manner as it did the glass in the last experiment, but of a redder color.

656. *Protoxyde of iron. Martial Æthiops.* ($\mathrm{Fer} + \mathrm{O} = 36.$)—Add potass to a solution of the ordinary green vitriol, (protosulphate of iron.) The powder precipitated is quickly placed in a crucible, and made red hot as much as possible out of contact with the air. Until heated, the precipitate is white, being an hydrated protoxyde. The result is the protoxyde, a black powder. The black powder left after burning iron wire in oxygen is also the protoxyde. *Ex.* 224 and 222. It is however best procured by *Ex.* 246. By whatever method it is procured, it almost always contains or becomes soon changed into the peroxyde.

657. *Peroxyde of iron, saffron of mars, crocus martis, jeweller's rouge, colcothar, &c.* ($\mathrm{Fer} + \mathrm{O}\ 1\frac{1}{2} = 40.$)—Put green vitriol in a crucible or ladle, and give it a red heat for two or three hours, the red powder which remains is the peroxyde of iron.

658. Dissolve iron in aqua-regia, precipitate by adding potass—a bulky brown precipitate of *hydrated* peroxyde of iron falls; which, when dried, assumes a deeper color, and is the anhydrous peroxyde.

659. Burn in a crucible iron filings and nitre in equal portions; wash the residuum.

660. *Protoxyde of zinc.* ($\mathrm{Z} + \mathrm{O} = 40.$) *Nihil album, philosopher's wool, flowers of zinc.*—To a solution of white vitriol (sulphate of zinc) add ammonia. Wash and dry the precipitate at a red heat; it is useful as a pigment, and is employed in medicine as a tonic and astringent in external applications. It may also be obtained by combustion.—See *Ex.* 230, 467, 468 and 469,

661. *Protoxyde of tin.* ($\mathrm{Sta} + \mathrm{O} = 66.$)—To a solution of protochloride (muriate) of tin add ammonia, when the protoxyde falls. It must be washed and heated to redness to drive off its water. It is a grey powder.

662. *Sesquioxyde of tin.* ($\mathrm{Sta} + 1\frac{1}{2}\mathrm{O} = 70.$)—" When a saturated solution of peroxyde of tin in hydrochloric acid is mixed with moist hydrated peroxyde of iron, an interchange of elements takes place, by which chloride of iron and sesquioxyde of tin are formed; its solubility in ammonia distinguishes it from protoxyde, and its giving a purple precipitate with perchloride of gold from the peroxyde." —*Brande.*

663. *Peroxyde of tin, putty powder, &c.* ($\mathrm{Sta} + \mathrm{O}\ 2 = 74.$) — Stir up the protoxyde made hot in a crucible, with a red hot iron rod or wire, and it will become changed into the peroxyde. The agitation bringing the particles of protoxyde in contact with the air, and the heat of the wire assisting the combination of it with the oxygen.

664. Keep metallic tin in a state of fusion, and take off the dross or oxyde as it forms upon the surface. This dross ground up and washed in water to separate any metallic particles is the peroxyde of tin. Throwing occasionally a little nitre into the crucible will materially facilitate the formation of oxyde.

665. Suffer a solution of chloride of tin, or indeed of any salt of tin, to remain for some time undisturbed, and it will deposit the peroxyde in the state of a white powder, or it may be thrown down immediately by adding ammonia to the solution. Thus made, it is until heated an hydrated peroxyde.

666. *Protoxyde of cobalt.* ($\mathrm{Cob} + \mathrm{O} = 38.$)—Add an alkali to a solution of the nitrate of cobalt, wash and dry the precipitate; when first precipitated it is blue, if left in contact with water, it becomes red, and afterwards by absorbing oxygen green, finally, when dried purplish black. This, in an impure state, constitutes *zaffre.*

667. Perform the *Ex.* 654 and 655, but with cobalt instead of manganese, and a fine blue color will be given to the glass and clay. With any oxyde of tin the color given would be of a pure white.

668. *Peroxyde of cobalt.* ($\mathrm{Cob} + \mathrm{O}\ 1\frac{1}{2} = 42.$)—Mix together solutions of chloride of cobalt and chloride of lime; a black precipitate falls, which is insoluble in acids.

669. *Protoxyde of nickle* ($\mathrm{Nic} + \mathrm{O} = 36.$) may be obtained by heating the nitrate or carbonate of nickle to redness in an open crucible. Its color is grey and most of its salts have a green color.

670. Add potass to a solution of any salt of nickle, when the protoxyde in the state of a hydrate will be precipitated of a fine green color. It is afterwards to be made red hot, when it becomes grey.

671. *Peroxyde of nickle* ($\mathrm{Nic} + \mathrm{O}1\frac{1}{2} = 40.$) may be prepared by transmitting chlorine through water, in which the oxyde is diffused in fine powder; a portion of this liquid is decomposed, the hydrogen combining with the chlorine, and the oxygen with part of the oxyde of nickle, converting it into the peroxyde which is left undissolved. There are no salts of this oxyde.

672. *Suboxyde of copper.* ($\mathrm{Cu}2 + \mathrm{O} = 72.$)—A suboxyde is one in which the atoms of oxygen are less in number than those of the base; there is one of copper of a brown color, known familiarly as the bronze-like substance which gives the color to tea urns and other articles. It may be procured by digesting 50 parts of finely divided metallic copper, and 58 of peroxyde of copper in 400 of hydrochloric acid. When potass is added to this solution, an hydrated compound of an orange

color falls, if quickly dried out of contact with the air it becomes of a red brown.

673. *Bronzing copper vessels, &c.*—First clean the surface of the vessel, and then brush it over with either a solution of sulphate of iron, or acetate of copper, or else with the peroxyde of iron mixed with water. Heat it then cautiously and equally, until it is found upon rubbing off the slightly adherent powder that the vessel is of a proper color.

674. *Bronzing medals.*—2 parts of verdigris and 1 of sal ammoniac are dissolved in vinegar; the solution is boiled in a pipkin, skimmed and diluted with water till it only tastes slightly of copper, and ceases to deposit a white precipitate; it is then poured into another pipkin and rapidly brought to boil, and the medal being previously cleaned is dipped into the boiling solution, placing it in a wire basket for that purpose. The surface of the medal becomes at first of a black or dark blue color, and then in about five minutes acquires the wished-for tint; it must be now instantly withdrawn, washed and dried. When there are several medals, each must be done separately.

675. *Protoxyde of copper.* ($Cu+O=40.$)—Heat a bar of copper in the fire, and when red hot, plunge it into cold water, black scales fly off, which are the protoxyde, a perfectly black powder. When the protoxyde is thrown down from the solutions of copper by adding alkali to them, it is in the state of a blue powder, but which becomes black by exposure to the air. The peroxyde is the base of all the salts of copper.

676. *Protoxyde of lead.* ($Pl+O=112.$) *massicot, litharge.*—Take off the dross which forms on the surface of melted lead, and having procured a quantity, heat it gently in a ladle, when it will become first red, but when cold, yellow; constituting the well-known pigment, called *massicot*. If this be subjected to a strong red heat it will fuse, and turn red. In this state it is called *litharge*, a substance which boiled with oil gives it a drying quality, and is therefore much employed by the painter.

677. Expose white lead to a strong red heat; the carbonic acid which forms part of its composition flies off and leaves the protoxyde.

678. Dissolve some of this oxyde in lime-water, in which it is sparingly soluble, filter the solution, and preserve it. It is recommended as a good stain for hair.

679. Mix together this oxyde, and some pulverised calcined flints or fine sand, and submit the mixture to a strong heat in a crucible; they will fuse together and form a kind of glass of a blueish color.

680. *Deutoxyde of lead, sesquioxyde of lead, red lead, minium.* ($Pl+O\,1\frac{1}{2}=116.$)—This well-known material is made by exposing massicot to a powerful heat, agitating it at the same time, that each part may in turn receive oxygen from the air with which it is in contact.

681. *Peroxyde of lead.* ($Pl+O\,2=120.$)—Let red lead soak for some time in nitric acid, when it will lose its fine red color and become changed into the brown peroxyde, having absorbed oxygen from the acid.

It may be procured also by suffering a stream of chlorine to pass through a mixture of red lead and water, or through a solution of acetate of lead.

682. Let a portion of the peroxyde of lead be triturated in a mortar with ⅕ of its weight of sulphur. If the mortar be hot, the bodies will unite with so much rapidity as to burst spontaneously into flame.

683. *Protoxyde of antimony.* ($An+O\,1\frac{1}{2}=77.$)—Fuse metallic antimony in a ladle, and keep it in a fused state and at a red heat exposed to the air. It will be gradually converted into the protoxyde, and which, if proper apparatus be used, will be sublimed in long and delicate needle-shaped crystals; otherwise it is in the state of a white powder, formerly called *Argentine flowers of antimony*.

684. Dissolve emetic tartar (which is the tartrate of antimony and potass,) in water, and add ammonia, heat the mixture, and wash the precipitate in large quantities of boiling water.

685. *Protoxyde of bismuth.* ($Bi+O=80.$)—Melt some bismuth in a crucible, and expose it freely to the air; a crust soon collects upon its surface, composed principally of the oxyde of bismuth.

686. The protoxyde of bismuth is better prepared as follows:—Dissolve bismuth in nitric acid, then add water, the effect of which will be to throw down the subnitrate of bismuth in a yellowish white powder; put this into a crucible and submit it to a red heat, when the remains of the nitric acid being volatilized, the protoxyde only will be left in the crucible. This is the base of the salts of bismuth.

687. *Sesquioxyde of bismuth,* ($Bi+O\,1\frac{1}{2}=84.$) is prepared by fusing potass and the oxyde of bismuth together, dissolving away the potass afterwards by water.

Oxydes of arsenic. See *Acids.*

688. *Protoxyde of mercury.* ($Hy+O=208.$) *Black, or ash-colored oxyde of mercury.*—Rub together in a mortar for a quarter of an hour, calomel and a solution of potass,

taking care to have an excess of alkali; the oxyde will subside, and may be separated by filtration and washing. It may also be prepared, but less conveniently, and with less certainty, by boiling calomel (protochloride of mercury) with lime water. It is thought that it is in the state of protoxyde that mercury exists in *blue pill* and mercurial ointment, though others advocate the opinion, that in these preparations mercury is in merely a finely divided state, and not oxidized.

689. *Peroxyde of mercury*, ($\mathrm{Hy} + \mathrm{O}\,2 = 216$.) *binoxyde of mercury, precipitate per se, and red precipitate.*—Expose mercury to a heat of between 500 and 600, and it will gradually change into a red, scaly powder. Dr. Reid says, "that upwards of a fortnight is necessary to prepare a few grains of it by this method." The following may therefore be adopted in perference:—

690. "Dissolve 3 parts of mercury in 2 of nitrous acid, diluted with an equal bulk of water, evaporate the solution to dryness, and expose it to heat in a crucible till it assumes a deep red color. In this process the metallic mercury decomposes part of the nitric acid, and is converted into binoxyde of mercury, which combines with the remainder of the acid, so that the dry mass, which is obtained in the first stage of the process, is a compound of nitric acid and the binoxyde of mercury. The nitric acid is afterwards almost entirely expelled, being resolved by the heat into nitrous acid and oxygen gases."—*Reid's Chemistry.*

691. *Oxyde of silver.* ($\mathrm{Arg} + \mathrm{O} = 116$.)—Add solution of potass to a solution of nitrate of silver, when the oxyde of the metal will be deposited in the state of a dark olive-colored tasteless powder, which when gently heated, or exposed to light, becomes changed to a black color, which is metallic silver in a state of extremely fine division.

692. *Protoxyde of gold.* ($\mathrm{Au} + \mathrm{O} = 208$.)—Add solution of potass to a solution of protochloride of gold, the product must be washed with water, and dried at the temperature of the air, otherwise it becomes converted into peroxyde and metallic gold. It is of an olive color.

693. *Deutoxyde of gold. Purple oxyde of gold.*—This is only to be procured by passing an electrical shock through gold leaf, the leaf will be melted and deposited in the state of a purple oxyde on the surface of two pieces of glass, inclosing the gold leaf during the passing of the shock. It is doubtful if this be an oxyde at all.

694. *Peroxyde of gold.* ($\mathrm{Au} + \mathrm{O}\,3 = 224$.)—According to Pelletier, "the best process for obtaining the peroxyde of gold, is to add magnesia to a solution of the perchloride of gold, then it is to be washed with dilute nitric acid to remove any excess of the precipitant, and drying it at a very low heat. From its power of combining with the alkalis, it is often called *auric acid.*"

695. *Suboxyde of platinum.* ($\mathrm{Pl}\,2 + \mathrm{O} = 104$.)—"When nitrate of mercury is added to a dilute solution of perchloride of platinum, a powder falls, which, when carefully heated, gives off calomel, and leaves a black oxyde of platinum, which forms the base of an excellent black enamel."—*Brande.*

696. *Protoxyde of platinum.* ($\mathrm{Pl} + \mathrm{O} = 104$.)—Mix together solutions of caustic potass, and protochloride of platinum; the result will be that the protoxyde of platinum will be thrown down, and the hydrochlorate of potass remain in solution. The oxyde may be washed, and afterwards dried at a temperature of not exceeding 100°.

697. *Sesquioxyde of platinum.* ($\mathrm{Pl} + \mathrm{O}\,1\tfrac{1}{2} = 108$.)—Mix together equal parts of caustic potass, and spongy platinum, heat them in a crucible to redness,—wash the product when cold with water,—a grey powder will be obtained, which is the sesquioxyde of platinum. It had better be purified from any adhering alkali, by washing it in diluted nitric acid, and afterwards in water, drying at a gentle heat.

698. *Peroxyde of platinum.* ($\mathrm{Pl} + \mathrm{O}\,2 = 112$.)—Boil perchloride of platinum in sulphuric acid, to form persulphate of platinum; then mix with it nitrate of barytes, sulphate of barytes is thrown down, and pernitrate of platinum remains in solution. Now add caustic soda in small quantity; this forms a yellow precipitate, becoming brown when carefully washed and dried. It is an hydrated peroxyde; heated in a retort it assumes a black color and becomes anhydrous.

EARTHS PROPER.

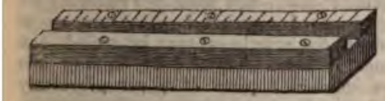
The earths proper are such as have neither alkaline nor acid principles. They are metallic oxydes, and are named glucina, zirconia, yttria, thorina, alumina and silica, being derived from the metals of correspondent names. The four first of these are too rare to be useful, the two last are well-known by the names of clay and flint. They may be obtained by heating their base and exposing it to the air, when the metallic substance, as we have seen in numerous other instances, will absorb oxygen, and be converted in a white powdery oxyde. This process, however, although practicable, would scarcely be resorted to, on account of the difficulty of obtaining the metal itself, and the much greater facility of procuring the oxyde from other and more abundant sources.

Ex. 699. *To procure pure alumina. Oxyde of aluminum.* (Al + O = 18.)—Take any quantity of ammonia-alum, which is the sulphate of ammonia and aluminum; put it in a crucible or ladle, and heat it to redness,—sulphate of ammonia and water evaporates, leaving the alumina pure.

700. *Second method.*—Dissolve alum in water, add to this carbonate of potass, (pearl-ash;) this precipitates a *hydrate* of alumina. Wash this with hot water, then redissolve it in diluted hydrochloric acid, and again precipitate, but with ammonia, instead of potass. Expose the fresh precipitate to a red heat, and pure alumina remains.

Alumina is white, tasteless, very light, rapidly absorbent of water, and has a strong affinity for various coloring matters; hence it is of great importance in dyeing. It shrinks very considerably in the fire, and is the basis of pipe-clay and other adhesive clays; hence, the great use of it in the manufacture of porcelain, white pottery ware, tobacco pipes, &c.

Ex. 701. *Contraction of by heat. Wedgewood's pyrometer.*—Construct a machine of the following character:—Let there be two pieces of iron or brass firmly fixed to a solid base, which is also of metal, the two sides being nearer together at one end than at the other; one of the sides is marked with degrees.



This constitutes Wedgewood's pyrometer, and is to be used as follows:—Take a piece of clay, or mixture of which clay forms the principal part, and make it into the shape of a brick, of such a size, that when it has been dried in the air, it will exactly fit the larger end between the sides. (A number of these bricks may be kept ready for use.) Place one of the bricks in a crucible and heat it, then suffer it to cool, and upon a fresh trial instead of exactly fitting the wider end of the instrument, it will slide down for a distance between the cheeks, proportionate to the degree of heat which the brick has previously received. Thus the heat of a furnace is at all times to be ascertained. The reason of alumina shrinking in the fire, is, that it contains much water, which it loses in proportion to the heat applied, and in some degree according to the length of continuance of the heat.

702. *To graduate Wedgewood's pyrometer.*—Immerse one of the pipe-clay bricks before spoken of in melted lead, and keep it there till it is of the same temperature as the lead, take it out, let it cool, and try it with the pyrometer; the distance it will advance between the cheeks will give the fusing point of lead or 660°. Try the same with zinc, tin, copper, cast iron, &c., and it will give those points in the scale at which such bodies fuse; a few of these being ascertained, the scale is easily constructed. Observe to use a fresh brick every time.

703. *Powerful attraction for water.*—If alumina be heated to redness, and accurately weighed then or as soon as cold, and suffered to remain in contact with a moist atmosphere, it will rapidly absorb water, until it has imbibed nearly half its weight as may be known by reweighing the alumina.

704. If a little perfectly dry or fresh burnt alumina be sprinkled with a few drops of water, they will be absorbed rapidly, the alumina becoming quite warm, similar to lime in the process of slacking. This rapid absorption of water is the reason that basins sometimes *sing* when warm water is poured into them. It also is the cause of fresh burnt tobacco-pipes adhering to the lips. Bricklayers will, upon the same principle, soak the finer kind of new made bricks in water, before using them, lest they should absorb too much of the moisture of the mortar or cement to be used with them. This is particularly the case with such bricks as are used for the arches over doors and windows; thus the mortar remaining more fluid, enables the workman to make a closer joint.

705. *Manufacture of lakes and carmine.*—What are called lake colors are coloring matters combined with alumina. This earth having such an affinity for coloring matter, that upon precipitating it from its solutions, it carries the color with it. The following is an example:—Boil cochineal in water until its color is extracted, dissolve some alum, (which is a salt containing alumina) in this infusion, and then add ammonia. This will abstract the sulphuric acid of the alum, and suffer the alumina to fall down; in doing so it will carry down the color of the cochineal, and leave the liquid clear and colorless. The precipitate is carmine. Numerous other colors are made in the same way.

706. *Preparation of silica.*—Silica, or the earth of the supposed metal silicium, may be procured as explained in *Ex.* 32. If required in a fine powder, a pure silica may be procured thus:—Fuse together fine white sand, or powdered rock crystal, with carbonate of lime, pound the mass when cold, and add diluted hydrochloric acid to it; the acid attacking the lime will suffer the silica to be precipitated in a very fine white powder.

Silica, from its property of forming a compound with the alkalis, is sometimes called the silicic acid, and its compounds silicates; thus glass of all kinds is the *silicate* of potass, or silicated potass. See *Salts*.

ALKALINE EARTHS.

The four alkaline earths,—lime, baryta, strontia, and magnesia, are oxydes, the oxygen being naturally combined with the difficulty procurable metals calcium, barium, strontium, and magnesium. There are earths however obtained with great facility from their compounds, which are sufficiently abundant. Lime of all other bodies in the creation perhaps the most so, if we except flint, and perhaps even without this exception. Limestone, marble, and chalk, are the chief sources whence we obtain this valuable earth; the making of mortars and cements its chief use.

Ex. 707. *To obtain pure lime, oxyde of calcium, quick lime.* ($\mathrm{Cal} + \mathrm{O} = 28$.)—Place a few small pieces of white marble in a crucible, and subject them to a red heat for an hour. This will drive off the carbonic acid from the marble, which is a carbonate of lime, and leave the lime pure.

708. *To make lime cylinders for the Drummond or lime light, or for the oxyhydrogen microscope.*—File pieces of marble, or cut pieces of chalk into cylinders 1¼ inch long, and ¾ of an inch in diameter, put these in a crucible, and keep them in a red hot state for an hour, they will be calcined into quicklime. They must be kept in a well-stoppered phial.

709. *Hydrated oxyde of calcium, slaked lime.*—A compound of ¼ of water and ¾ of lime. Expose a piece of well and fresh burnt lime to the atmosphere, it will in a short time crumble into a white powder, and absorb its own weight of water. It is now slaked lime.

710. When a considerable quantity of lime is artificially slaked by water being thrown upon it, so much heat is generated, that very often a shaving may be lighted by contact with the lime.

711. *Combustion of in oxygen.*—Place a small piece of lime in a hole cut in lighted charcoal, as in *Ex.* 225; expose this to a stream of oxygen in the manner there represented, it will become incandescent, and give out the most intense light. If instead of charcoal the combustion of the lime be assisted by a stream of hydrogen as well as a stream of oxygen, the effect is still more brilliant, and constitutes the oxyhydrogen microscope, and also the Drummond, or koniophostic light.

712. *To make lime water.*—Throw a little lime into cold water, after remaining some time, and being stirred up, it is suffered to settle, and then the clear liquid being poured off, is fit for use. 750 grains of water will dissolve not more than 1 grain of lime.

713. Boil some of the cold lime water of the last experiment in a glass flask, it will, as it becomes hot, deposit a portion of its lime, which will be absorbed as the liquor cools; thus it is proved, that although cold water takes up a 750th part of lime, yet hot water will only dissolve a 1280th part. The lime thus deposited is in the form of very minute crystals; a pint of boiling water dissolving about 6¾ grains, a pint of freezing water 13¼ grains.

Union of lime with charcoal. See *Ex.* 355.

714. *Alkaline properties of lime.*—A substance is known to be alkaline when it changes the yellow color of turmeric powder to a brown, and certain vegetable blue colors to green. This may be proved of lime by adding lime water to water in which red cabbage has been boiled, and to water in which turmeric has been soaking.

Note.—This is the first time in which we have had occasion to combine two solutions together, to form a test of the properties of one of the component bodies. Although the important subject of testing will shortly occupy our peculiar attention, it may be advisable to state, that when two solutions are to be mixed together for the purpose of testing, the experiment may be varied, and generally much simplified by dipping into one solution a piece of paper previously soaked in the second solution. For example, a piece of paper dipped in turmeric water, and others dipped in the water of red cabbage, may be always kept ready, and a small strip torn off for immediate use at any moment.

715. *Cream of lime and milk of lime.*—These are nothing more than slaked lime, added to water, until it forms a thick cream-like liquid—in fact it is but a more refined name for *lime white*, such as walls are whitened with.

716. *Antiseptic properties of lime.*—Eggs left to soak for an hour or two in lime water have thereby the pores of their shells filled up with the lime, and therefore being less porous, and consequently less susceptible of atmospheric influences, they will keep for a much greater length of time than they otherwise would. Eggs packed in the powder of lime also keep better.

717. *Caustic character of lime.*—Soak the skin of any animal in lime water for a few days, or rather in cream of lime, when it will

be found that the hair may be easily separated. This is the first process in the art of tanning, the skins being thus cleaned previous to immersion in the tan pit.

Oil of lime. See *Chloride of Calcium.*

718. *Conversion of chalk into marble.*—Procure a strong cast-iron phial, holding 2 ounces, and closed by a screwed stopper. Fill this with chalk; screw on the plug or stopper, and throw the phial into the fire, a blacksmith's forge, a glass furnace, or any other which gives out intense heat. Suffer it to remain in the furnace for an hour, at the end of which time take out the phial, suffer it to get cold, then take out the stopper, when the chalk will be found a carbonate, as when put in, but much changed in hardness, adhesion, and semi-crystallized appearance, seeming exactly like pure white marble, and it is thought that heat and pressure combined, as in this experiment, have been the origin of marbles; chalk or limestone having became heated by volcanic action in situations where the carbonic acid cannot escape.

719. *Peroxyde of calcium.* ($\mathrm{Cal}+\mathrm{O}\,2=36.$)—Fasten a bladder of oxygen to the bottom of a vessel, containing quicklime at a red heat; suffer the oxygen to fill the interstices between the bits of lime, or better, continue to pour a stream of oxygen through the vessel, when the lime will gradually absorb oxygen, and become a peroxyde.

720. *Baryta. Barya. Oxyde of barium.* ($\mathrm{Ba}+\mathrm{O}=77.$)—Take the crystals of the nitrate, which are easily procured; put them into a crucible, and keep this at a red heat for an hour or more, according to the quantity operated upon. The nitrate will be decomposed, its acid fly off, and the oxyde of barium remain as a white powder.

721. Baryta may be made also from the carbonate, by submitting it to an intense and long-continued heat.

722. *Hydrated oxyde of barium.*—Sprinkle a little water on fresh burnt oxyde. It will, like lime, absorb and solidify the water, and crumble down into a bulky white powder, soluble in 20 parts of cold water and 3 of boiling water. The water of baryta, as well as nearly all its other preparations, are virulent poisons.

Note.—The alkaline properties of baryta are to be tried in the same manner as those of lime. (*Ex.* 713.)

723. *Peroxyde of barium.* ($\mathrm{Ba}+\mathrm{O}\,2=85.$)—Pursue the same process as for the peroxyde of lime, substituting baryta for lime.

724. *Protoxyde and peroxyde of strontian, and the hydrate of the protoxyde,* may be procured by the same processes as recommended for baryta. Strontia is alkaline, but not so caustic as baryta, and it may be instantly known by the very beautiful and brilliant red color which it and all its salts give to flame or burning materials when mixed with them. This is best tried with the nitrate of strontian, but it may be seen by letting fall a grain of the powder of strontia into the flame of a candle, a red color will be given out. If the same be tried with baryta, a yellow color will be communicated to the flame.

725. *Oxyde of magnesium, magnesia.* ($\mathrm{Mag}+\mathrm{O}=20.$)—Procured by exposing the carbonate of magnesia to a red heat. It is but slightly alkaline in its taste and effect upon colors, and is nearly insoluble in water. The hydrated oxyde may be obtained by adding potass to a solution of sulphate of magnesia; the earthy hydrate is precipitated.

THE ALKALIES.

The alkalies are binary compounds; the fixed alkalies are oxydes of the union of certain metals with oxygen. The volatile alkali ammonia is of totally a different origin, being the result of a combination of nitrogen with hydrogen. It is however included in this part of our subject for the sake of convenience, that the three alkalies may be compared the better together; as to the alkali called lithia, or the oxyde of lithium, it is so rare and little understood, that it may well be passed over in a work of this description. The alkali potass is obtained chiefly from terrestrial plants; soda is procured from marine productions; and ammonia, besides being an artificial production, emanates in numerous circumstances from animal substances. The alkalies have properties in common with the alkaline earths, but in a greater degree; they are rapidly absorbent of water and carbonic acid; change vegetable blues into greens, and yellows, particularly the yellow of turmeric, into a brown. They unite readily with acids, and in some cases with the metals. They are caustic, of a peculiar taste, and miscible with water in every proportion.

Ex. 726. *Anhydrous protoxyde of potassium or dry potass.* ($\mathrm{P}+\mathrm{O}=48.$)—Inclose some of the metal potassium in a bottle of perfectly dry oxygen. It will change into a grey substance, fusible at a red heat, and volatile at a white one; united with water it forms the hydrated protoxyde.

727. *Hydrated protoxgde of potassium or caustic potass.*—This is procured in our laboratories by decomposing carbonate of potass by lime. The best process is as follows:—Boil in a clean iron vessel 2 parts of pearlash with 1 of quick lime in water, adding the lime gradually, and frequently stirring the solution. After boiling half an hour, set it aside

to cool and deposit the lime; filter through paper, evaporate the clear solution to dryness in a polished iron or silver pot—continue to apply heat until it fuses, when it may be cast into sticks; it is now the *potassa fusa* of the London Pharmacopœia. If it be required very pure, it may be dissolved in alcohol, which dissolves the pure hydrate, and leaves earthy and other impurities, the alcohol is then dissipated by heat.

728. *To procure potass from wood.*—Take the ashes of burnt wood and pour water over them, stir the mixture that the water may dissolve the potass contained in the ashes; suffer the grosser parts to settle, and when settled pour off the clear liquor. Boil this until as thick as brine, or rather until so thick as scarcely to be called a liquid. It may now be set aside, and when cold, will be found consolidated into a hard lump of impure carbonate of potass, called in the arts *grey* salts. When dissolved and boiled, and consolidated a second time, it is called *while salts;* this pulverized constitutes pearlash.

729. *Liquor potassæ* of the Pharmacopœia is directed to be prepared as follows:—Take of subcarbonate of potass a pound, fresh lime, ½ a pound, boiling distilled water, a gallon. Dissolve the subcarbonate in 2 pints of the water, add the remaining water to the lime, mix the hot liquors together, then set the mixtures by in a covered vessel, and after it has cooled, filter the solution through a cotton strainer; if effervescence be excited by dropping any diluted acid into the solution, more lime must be added, and the solution again strained. A pint of this solution ought to weigh 16 ounces troy.

730. *Deliquesces in the air.*—Suffer some dry potass to be exposed to the air, in a very few minutes it will become quite damp and soon melt away. When pearlash is thus dissolved, it is called oil of tartar per deliquium.

731. *Peroxyde of potassium.* $(\mathrm{P} + \mathrm{O}\,3 = 64.)$—A whitish yellow, or sometimes orange colored scaly substance, procured by burning potassium in oxygen gas. It may be burned as in *Ex.* 228, or 415, in the description of which experiments an error appears in describing the peroxyde of potassium as the usual alkali potass, which is as we have seen the protoxyde and not the peroxyde, a slow union of potassium and oxygen forming the first, and a more rapid union of the two the last.

732. *Peroxyde of potassium* may also be formed by fusing caustic potass in an open crucible, when oxygen is absorbed, so as to turn a part of it into the peroxyde.

733. Let a stream of oxygen gas pass through a tube filled with potass, and that kept at a red heat; it will become converted into the peroxyde of potassium.

734. Let a piece of potassium fall into melted nitre, the salt will be partly decomposed, the potassium seizing upon the oxygen of the acid with so much rapidity, as to be converted into the peroxyde.

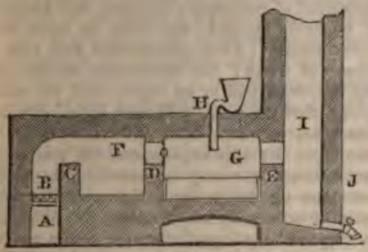
735. Put a little of the peroxyde of potassium in a cup of water, and a violent effervescence takes place, owing to the escape of oxygen, while the solution is one of the simple hydrate of potass.

736. *Protoxyde of sodium, soda, natron, mineral alkali, kali, barilla, &c.* $(\mathrm{So} + \mathrm{O} = 32.)$—This common article is produced from seaweeds and salsola; also from the carbonate of soda, and very extensively from common salt. Soda like potass is highly corrosive and alkaline, but the effect of the air upon it is totally different from that which occurs to potass; it is procured as follows:—Boil a solution of the carbonate of soda with half its weight of quick-lime, and after subsidence, decant the clear lye; then evaporate in a clean iron or silver vessel, till the liquid flows quietly like oil; it must then be poured out on a polished iron plate. It concretes into a hard white cake, which is to be immediately broken in pieces, and put up while still hot in a phial, which must be well corked. If the carbonate of soda be somewhat impure, then after the action of lime, and subsequent concentration of the lye, alcohol must be digested on it, which will dissolve only the caustic pure soda, and leave the heterogeneous salts. By distilling off the alcohol in a silver alembic, the alkali may then be obtained pure. The reason that silver and other metal articles are recommended in procuring the alkalies, is because they combine more or less with silica and alumina, consequently, act upon glass and porcelain utensils. The substance now procured is a hydrate of soda, containing nearly a quarter of its weight of water.

737. *To procure soda from sea salt.*—Sea salt, or common table salt, is a chloride of sodium; as sulphuric acid has a stronger affinity for soda than hydrochloric acid, it is added to the salt, the consequence is, that assisted by heat a sulphate of soda (Glauber's salts,) is formed, and the hydrochloric acid gas escapes. The sulphate is then mixed with chalk and common coal, in the proportion of 100 parts sulphate, from 110 to 120 chalk or limestone, ground into a powder, and pitcoal also ground 50 parts. These ingredients are submitted to a strong heat in a furnace, when two of them, namely, the chalk or carbonate of lime and the sulphate of soda decompose each other. The carbonic acid of the first seizes upon the soda, and of course reduces it

into the carbonate of soda. Pure soda is obtained from this carbonate, as recommended in the last experiment.

The furnace used for the conversion of the chloride into the sulphate of soda, on a large scale, is of the following peculiar construction, and made of the hardest and most refractory fire-bricks.



A is the ash-pit. B the grate. C D and E are three bridges or projections dividing the furnace into sections, of which the first marked F or that immediately behind the fire, is called the calcining hearth; while the other, marked G, is called the decomposing hearth. This hearth is lined with a square leaden pan, 6 or 8 inches deep, and has a leaden funnel through the roof, as marked at H. I is a round chimney, filled with round flint or gravel stones, such as are procured on the sea beach. These are kept continually moist by a small stream of water which trickles through them. There is a cock at the bottom of the chimney I, and also two doors through the sides of the furnace, communicating one with each hearth F and G. A fire being kindled in B, 3 cwt. of common salt is shovelled into G by the side door, and then 2½ cwt. of sulphuric acid poured upon it by the funnel H, the acid being previously diluted and well mixed with about a quarter of its quantity of water. Fumes of chlorine will now escape, and passing up the shaft I will be condensed by the water which moistens the flints, so that what flows from the cock I will be hydrochloric acid, while the mass remaining in G will be the sulphate of soda.

738. *To obtain soda from sea-weeds.*—Pursue exactly the same method as given for the obtaining of potass from wood, using any plants which grow in salt-water, or which are washed by the tide, particularly the plants called bladder fucus, serrated fucus, &c. The Spanish barilla is an impure soda obtained from the salsola kali, a plant common and abundant on the Spanish shores of the Mediterranean.

739. *Peroxyde of sodium.* ($\text{So}+\text{O}_2=40$.)—To procure the peroxyde, pursue exactly the same method as that for obtaining the peroxyde of potassium, which has the same general properties; also, all the experiments given under prot- and peroxyde of potassium may be tried with this alkali; the following with a very different effect.

740. *Effloresces in the air.*—Expose some soda to the air, after a short time it will be covered with a white powder, and eventually change wholly into it.

741. *Ammonia, volatile alkali, spirits of hartshorn, and terhydruret of nitrogen.*—This, the third important alkali, agrees with potass and soda in its effects upon vegetable colors, and in the general nature of its combinations; but differs wholly from them in its composition and in its form, being a gas absorbable by water, and containing no oxygen, but is a compound of nitrogen and hydrogen—three atoms of the latter uniting to one of the former; its symbol is therefore $\text{N}+\text{H}_3=17$. (Amm is a more convenient symbol.) The solution of ammoniacal gas in water forms the *liquor ammoniæ*, or spirits of hartshorn of the shops.

742. *To procure pure ammoniacal gas.*—Mix unslaked quicklime with its own weight of sal ammoniac, each in fine powder, and introduce them into a glass retort. Join to the beak of the retort, by a collar of Indian rubber, a glass tube, about 18 inches long, containing pieces of red-hot chloride of lime. This tube should lie in a horizontal position, and its free end dip beneath the surface of mercury in a pneumatic trough, or else have a bladder, which is dry inside, attached to it. The retort should have a safety tube attached to it, so that the whole apparatus is exactly that of *Ex.* 646. Upon the heat of a lamp being applied, the gas will rapidly rise, and after the heat has expelled the atmospheric air first contained in the apparatus, let the bladder be attached, and the gas will rapidly fill it.

743. *To procure ammonia from animal substances.*—Put into a retort bones, horns, hoofs, or other animal matter, and carefully apply heat; the peculiar pungent smell of ammonia will soon become apparent, and if the beak of the retort be dipped beneath the surface of water in a basin, the water will absorb the gas, and gradually become liquid ammonia. From this method of preparation, ammonia is often called *spirit of hartshorn*, the scraps of horn cast aside by the cutlers being the raw material once employed.

744. *To procure ammonia from coals.*—During the process of distillation of coals in the making of coal gas for illumination, a great quantity of ammoniacal gas and carbonic acid gas are given off, these containing much vapor deposit themselves as ammoniacal liquor, which is a solution of impure carbonate of ammonia; this subjected to the

action of sulphate of lime (plaster of Paris) newly burnt and ground, is converted into sulphate of ammonia. Hydrochloric acid being added, decomposes the sulphate, and forms hydrochlorate of ammonia, this is afterwards treated as in *Ex.* 742.

745. *Third method.*—The following process, recommended by Mr. R. Phillips, answers:—On 9 ounces of well-burnt lime pour ½ pint of water, and when it has remained in a well-closed vessel for about an hour, add 12 ounces of sal ammonia in powder, and 3 pints and ¼ of boiling water, when the mixture has cooled, pour off the clear portion, and distil from a retort 20 fluid ounces. The specific gravity of this solution, which is sufficiently strong for most purposes, is 0·954, very nearly equal to that recommended in the Pharmacopœia, which is 0·960. It must be kept in stoppered bottles.

746. Put a little liquid ammonia in a Florence flask, fasten a narrow tube, such as a tobacco pipe, through a cork which fits the mouth of the flask; when the heat of a lamp is applied beneath the flask, the gas will issue with rapidity.

747. *To collect the gas.*—Hold over the orifice of the tube in the last experiment, a perfectly dry flask or tube, with its mouth downwards. The gas will soon fill the upper tube, and while its mouth remains downwards will not escape. It may be corked, but a cork is too porous to retain the gas long.

748, *To ascertain that the upper flask is full of gas.*—Hold near the mouth of the flask a feather dipped in hydrochloric acid; this will combine with the ammoniacal gas, and the fumes of both, before colorless, will unite, and put on a perfectly white appearance. As the ammoniacal gas is lighter than atmospheric air, this effect will not take place till the upper flask is full of the gas, atmospheric air only escaping at first.

749. *To condense the gas.*—Perform the *Ex.* 285 and 286 with ammoniacal gas, instead of chlorine, using distilled water, and the same apparatus, a solution of ammoniacal gas will be obtained. Water, at a temperature of 60°, thus absorbs about 800 times its own bulk of the gas.

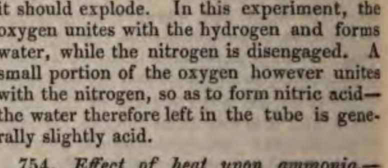
750. *Soluble in alcohol.*—Instead of distilled water, wherewith to condense the gas, use alcohol. This will absorb a great quantity of the gas, and form the *alcohol ammoniacum* of the Edinburgh College.

751. *Action upon salts of copper.*—Make a very dilute solution of blue stone, (sulphate of copper;) so very dilute indeed that it scarcely appears colored. Use this solution to fill the bottle in which it is desired to condense the gas. The gas will be absorbed, and as it is so, it will first make the solution turbid, by seizing the sulphuric acid, making with it the sulphate of ammonia. Then it will seize the oxyde of copper, forming an ammoniuret of that metal, which while in solution is of a most beautiful blue color.

752. *Rapid absorption by water.*—Fill a long glass tube, closed at the upper end, with ammoniacal gas, as in *Ex.* 747. When it is *quite* full of gas remove the tube, still keeping it perfectly upright, and with its open end downwards. Then plunge this end into a vessel of water; the absorption of the gas by the water will be so rapid, and so complete, that the water will rush with force up the tube, and completely fill it, even up to the top. By this experiment the purity of ammoniacal gas may be ascertained; for if common air be present, the quantity of it may be accurately measured by the extent it occupies at the top of the tube at the end of the experiment.

753. *Ammonia explodes with oxygen.*—Mix together in a strong tube or phial, 2 measures of ammoniacal gas and 1½ measure of oxygen. Uncork the phial near a lighted candle, or apply a lighted match to the combined gas, which will immediately explode with a loud report. To prevent accident, the phial should be wrapped in a cloth, lest it should explode. In this experiment, the oxygen unites with the hydrogen and forms water, while the nitrogen is disengaged. A small portion of the oxygen however unites with the nitrogen, so as to form nitric acid—the water therefore left in the tube is generally slightly acid.

754. *Effect of heat upon ammonia.*—Attach a bag containing ammoniacal gas to one end of a small gun barrel, filled with scraps of iron, and to the other end attach a second bag; but before the second bag is attached, the gun barrel must be passed across a fire, and must be made red hot. The second bag being in its place, squeeze the ammoniacal gas over the surface of the red hot tube; it will become decomposed into its two constituents, hydrogen and nitrogen. The mechanical mixture of these will be formed in the second bag, and will be found to occupy a much greater space than the ammonia, in the proportion of 18 measures of the mixed gases to 10 of the ammonia. The word bag, by which is understood one



of oiled silk or caoutchouc, is here recommended instead of a bladder, because the latter cannot conveniently be used, unless wetted, and as we have seen, the water within it, be it ever so small a quantity, will absorb much, if not all of the ammonia.

755. *Ammonia decomposed by chlorine.*—Make some chlorine in a flask, *Ex.* 281, and let it pass in a gaseous state into a very strong solution of ammonia in a phial; each bubble of gas as it touches the liquid will decompose a portion of the ammonia, and in doing so will burst into a slight flame and explosion. A view of the apparatus is given in *Ex.* 87.

756. *Second method.*—The above experiment may be reversed, and gaseous ammonia be passed into an aqueous solution of chlorine; the ammonia will inflame, and continue to burn with a pale lilac flame, producing hydrochlorate of ammonia, and giving off nitrogen.

757. *Third method.*—Fit two bottles or flasks with the same cork, one to each end, and let a glass tube, with a narrow bore pass through the cork, projecting on each side of it. Let the bottles be perfectly dry, and fill one of them with chlorine, and the other with ammonia. Fit them thus filled to the cork, as in the annexed cut, being careful to keep the bottle of ammonia with its mouth downwards, and that of chlorine with its mouth upwards. When fastened on, turn the whole upside down, so that the ammonia bottle may be the lower. The gases will combine, and the ammonia burn with a lambent flame. The reason of reversing the bottles will be apparent; the ammonia being the ligher, neither gas would have any tendency to alter its position in the apparatus; but upon reversing the bottles, the chlorine now at the top sinks through the ammonia, and the ammonia rises into the chlorine; being thus brought into contact, decomposition takes place.

758. *Fourth method.*—Pour a solution of ammonia into a solution of chlorine, an effervescence ensues, nitrogen gas is evolved, and the hydrochlorate of ammonia is formed.

759. *Fifth method.*—Professor Brande observes, "The best mode of showing the mutual action of ammonia and chlorine in solution is to pour into a tube about 2 feet long, and ½ an inch in diameter, sealed at one end, a strong aqueous solution of chlorine, to within about 2 inches of the top; then gradually to pour upon it liquid ammonia so as to fill the tube, which is to be closed by the thumb, and inverted into water. The solution of ammonia then rises through that of chlorine, and is decomposed with effervescence, nitrogen being evolved."

760. *Does not support combustion.*—Immerse a burning taper in a jar of dry ammoniacal gas, it will be immediately extinguished, but as the flame is itself somewhat combustible the flame of the taper will be enlarged previous to its extinction.

761. Ammoniacal gas for an experiment of this kind may be easily procured, by pounding together in a mortar, 2 parts of quick-lime, and 3 of sal ammoniac. A pungent odour arises. This is the gas and it may be collected by merely inverting a tube, flask, or bell-glass over the mortar.

762. *Freezing ammonia.*—Perform *Ex.* 503 with a strong solution of ammonia instead of mercury, and at the same degree of temperature, namely 40° below zero,—or, as Dr. Ure observes, "at 50°"; the ammonia loses its odour, and gelatinizes if cooled suddenly, but if slowly cooled it crystallizes.

763. *Ammonia oxydizes zinc.*—Zinc is the only common metal that ammonia oxydizes and then dissolves, though it combines with the oxydes of numerous others; thus when granulated zinc has liquid ammonia poured upon it, it is gradually dissolved, forming an ammoniuret of that metal.

764. *Effect of ammonia upon ice.*—Fill a soda-water bottle with ammoniacal gas, and drop into it a piece of ice; the ice will be almost immediately dissolved, at the same time great cold is given out.

765. *Ammoniacal gas does not support animal life.*—The life of an animal dropped into a jar of ammoniacal gas is instantly extinguished.

BINARY ACIDS.

This important class of chemical substances, though in most cases compounds of oxygen with some base, do not all contain this element as their acidifying principle. Combinations of hydrogen with sulphur, fluorine, and bromine, have acid characters; so have also some of the compounds of chlorine. The ancient supposition therefore that oxygen, the name of which is derived from *oxus*, sharp or sour, is the only acidifying principle is evidently erroneous; although it must be admitted, that in most acid products oxygen is present; thus all the metallic acids are oxydes, so are most of the vegetable acids, the acetic, tartaric, citric, &c., but with the difference that in the metallic acids oxygen unites with a single base, (water not being accounted,) whereas most of the vegetable and animal acids are composed of three substances, oxygen being united with both carbon and hydrogen. Besides the above sources of the acids, oxygen forms acids with the non-metallic elements, and even with such of them as by their union, without its assistance, form some of the same class, as oxygen and hydrogen, oxygen and chlorine, oxygen and iodine, oxygen and sulphur, &c. To arrange a class of chemical bodies of such different origin and composition is extremely difficult; it will, perhaps, most conduce to simplicity to consider all the combinations of three elements hereafter, and to confine our attention at present to the binary acids, and first to those with oxygen as their acidifying principle.

An acid is popularly known as any thing which is *sour*. This definition is not sufficiently distinct and accurate, as although it is admitted that all sour bodies are acids, yet all acids are not sour. Chemists include under the term acid all substances which redden vegetable blue colors, and which are capable of combining with an alkaline, earthy, or metallic base, forming by such a combination a neutral salt; that is, a salt which is neither alkaline nor acid. In all cases of acid products, it is evident that there must be a greater proportion of the acidifying principle than exists in the neutral compound, if there be one. For example, oxygen unites with nitrogen in five proportions, (as was explained in page 85,) forming two oxydes and three acids. The oxydes are the nitrous and the nitric, both neutral—the acids are the hyponitrous, the nitrous, and the nitric. The particular mode of expression is here to be noted; for in all cases it is to be understood, that when the name of an acid or an oxyde ends in *ous*, it contains less oxygen than if ending in *ic;* and generally speaking, still less if *hypo* be prefixed to the specific name of the acid, as in the above instance. If *hyper*, *per*, or *oxy* be prefixed, it indicates a still higher degree of acidity; thus we speak of the hyper-, per-, or oxychloric acid.

Ex. 766. *Euchlorine, protoxyde of chlorine, hypochlorous acid.* ($C+O=44.$)—A deeply yellow-colored gas, absorbable by water; of a strong penetrating odour, of nearly three times the specific gravity of atmospheric air. To obtain it, mix in a small retort or flask 2 parts of chlorate of potass and 1 of hydrochloric acid, diluted with an equal quantity of water. A very gentle heat will extricate the gas, causing at the same time an effervescence with the material; it may be collected in a dry state, or combined with water, by an arrangement of apparatus similar to the foregoing. If the centre bottle be perfectly dry, the gas alone will occupy it; if partly filled with water, the gas will be absorbed.

Numerous of the experiments of euchlorine are of a highly dangerous nature; and in recording the few following, with the object of showing the character of the substance, we at the same time caution the young experimentalist to guard against explosion at all times, by care, by operating only with small quantities of materials, by wearing gloves, and as often as possible to shield the face with a wire mask such as is used by fencers, or if he prefer it a common paper mask furnished with glass eyes. Euchlorine often explodes spontaneously by the heat of the lamp used in making it, or even by the heat of the hand, the solar rays, &c. It cannot even be transferred from one vessel to another without danger; it should be operated upon chiefly in thick and small glass tubes. Also its fumes and its aqueous solution are highly corrosive of the skin.

767. Fill a small tube with euchlorine, drop a small piece of phosphorus in the gas, it will instantly burst into flame, and absorb the gas. The color of the gas will show when the tube is full.

768. Dip a burning taper or match into gaseous euchlorine, the flame will decompose the gas, and occasion a sudden and violent explosion.

769. The same may be tried with burning sulphur, or any other body on fire, or with a hot iron wire with the same result.

770. Try *Ex.*767 with sulphur, selenium, charcoal, or arsenic, instead of phosphorus, a similar detonation will take place, in consequence of the decomposition of the gas into its elements of chlorine and oxygen, which elements in a separate state occupy a greater space than when combined in euchlorine.

771. Instead of phosphorus in *Ex.* 767, use a little iodine, bromine, or indigo, the gas will be decomposed, not with violence, but slowly. After some time the change that has taken place will be seen by immersing a lighted match into the tube, when it will burn, in a manner similar to its inflammation in a mechanical mixture of these gases, not detonating as in *Ex.* 768.

772. Fill a small metal tube closed at one end, or still better a perfectly dry egg-shell

with euchlorine, the mouth or hole being uppermost when filling, then putting the finger covered by a glove over the hole, reverse the tube, dipping the hole of it in a cup of mercury—leave it thus, but place near it a spirit lamp, so that the tube or egg-shell may be gradually heated, the euchlorine gas, will at a slight increase of temperature, explode and be resolved into its elements, driving the tube or egg-shell upwards, sometimes up to the ceiling by the force of the explosion.

773. Make a solution of euchlorine in water, and dip any blue flower in it; it will in some cases change the blue into a red, and in other instances completely destroy the color altogether.

774. *Chlorous acid, peroxyde of chlorine.* $(C + O4 = 68.)$—This is even more explosive, and consequently more dangerous than the last. The experiments of the one may be tried with the other, when it will be found that of the unmetallic combustible substances, phosphorus is the only one which spontaneously decomposes this gas. It is of a deep yellow color, an astringent taste, and peculiar smell, very different from the last and much resembling that of burnt sugar. It may be made with safety only in minute quantities.

775. *To procure chlorous acid*, Dr. Reid recommends the following process :—" Put a few drops of sulphuric acid on to a grain or two of the chlorate of potass at the bottom of a glass tube, and hold it over a spirit lamp; when the deep color of the glass indicates that the tube is full, it may be exploded by introducing a bent wire previously heated." The tube though very small must be of considerable thickness, and should be inclosed in a wire pipe or guard, lest it should explode.

776. *To condense the gas.*—Professor Faraday condensed this gas by inclosing the mixture of chlorate of potass and sulphuric acid in a sealed tube, similar in shape to that described in *Ex.* 283, and leaving them to act upon each other for 24 hours. In that time there had been much action; the mixture was of a dark reddish brown, and the atmosphere within of a bright yellow color. The mixture end of the tube was then heated to 100°, and the free end cooled to 0°. By degrees the mixture lost its dark color, and a very ethereal-looking yellow fluid condensed. This was the peroxyde of chlorine.

777. *Chloric acid, hyperoxymuriatic acid.* $(C + O\,5 = 76.)$—This cannot exist except in the state of a solution. It may be prepared as follows :—Add dilute sulphuric acid to a solution of chlorate of baryta, as long as it occasions a precipitate; this being suffered to subside, the clear liquor may be poured off; it contains chloric acid in solution. It is a sour colorless liquid, not occasioning precipitates when added to solutions of metallic salts. It is this combination of oxygen and chlorine which unites with various bases, constituting the salts called ***chlorates***, or formerly oxymuriates. (See ***Chlorates.***)

778. *Perchloric or oxychloric acid.* $(C + O\,7 = 92.)$—Distil perchlorate of potass with its own weight of sulphuric acid, diluted with one-fourth its weight of water. The white vapors which pass off condense into a colorless liquid; by distilling this liquid with sulphuric acid the perchloric acid may be acquired in a much more concentrated, solid, and crystallized form.

779. *Iodous acid.*—Put together in a retort 1 part of iodine and 3 of chlorate of potass, and apply heat rapidly. The iodous acid, which is a dense fluid, distils over into the receiver, and must be cooled by a freezing mixture.

780. *Iodic acid.* $(I + O\,5 = 165.)$—Suffer a small stream of euchlorine from a retort to pass into a tube, containing a few grains of iodine; some pieces of chloride of calcium being put into the neck of the retort. An evolution of light and heat takes place when the euchlorine comes in contact with the iodine, one portion of which combining with the oxygen of the euchlorine is converted into iodic acid, while the remainder unites with the chlorine, forming a compound which is easily separated from the iodic acid by a moderate heat.

781. *Second method.*—Boil for several hours iodine with strong nitric acid in a tube 12 or 15 inches long, holding the tube erect, washing down again any sublimed portion of iodine which may settle in the upper part of the tube. Iodic acid is a white semi-transparent solid, having a very acid astringent taste. Its salts are called *iodates*.

782. *Periodic or oxiodic acid.* $(I + O\,7 = 181.)$—Add pure soda to a solution of iodate of soda, pass chlorine to saturation through the solution, and evaporate, until a salt, which is the periodate of soda, is obtained. Dissolve this in dilute nitric acid, then add nitrate of silver, a yellow precipitate falls, which dissolved in hot nitric acid and evaporated, yields orange-colored crystals of periodate of silver. These crystals are decomposed by cold water, a yellow periodate of silver falls, and an aqueous solution of pure periodic acid is formed, which yields crystals of the hydrated periodic acid by evaporation.

783. *Bromic acid.* $(B + O\,5 = 118.)$—This, which is the only compound of oxygen and bromine, may be obtained from the bromate of baryta, by adding sulphuric acid to it as long as a precipitate falls, being careful not to add any access, otherwise the

bromic acid left in the supernatant liquor will be contaminated. Its salts are *bromates*.

784. *Hyponitrous acid.* $(N+O_3=38.)$ Gay Lussac, the discoverer of this liquid acid, says, "that it may be obtained by the distillation of the nitrate of lead, it passes over in the form of a red vapor, condensable in a receiver surrounded by ice. It is of no general application or use."

785. The above method of obtaining this acid is liable to form nitrous acid, instead of or at least mixed with the hyponitrous. The following method is therefore preferable:—Mix ½ a measure of dry oxygen with 2 measures of nitrous oxyde gas. This produces an orange mixture, somewhat similar to that of the last experiment. When forced through a tube, surrounded by a freezing mixture, the color diminishes, becomes greenish, and the hyponitrous acid condenses into a liquid. It will be seen that the mode of obtaining this acid differs very little from that of procuring the nitrous acid, nor are the acids themselves very dissimilar; the present is greener in color and more volatile.

786. *Nitrous acid.* $(N+O_4=46.)$—This which is the acid principle of the salts called nitrites is seldom made purposely for experiment, but is liberated during numerous chemical processes. It may be obtained by the distillation of the nitrate of lead, or as follows:—Mix together in an exhausted receiver, 2 volumes of nitric oxyde and 1 of oxygen, the gases will spontaneously combine, and form this acid in a gaseous state. This when cooled by being surrounded by a freezing mixture will change to an orange-colored liquid, if it be lowered to a temperature of 0°. A very pretty way of illustrating this fact is by the following apparatus:—A is a glass globe with 3 orifices, B C and D. To B is fastened a condensing syringe, that the globe A may be exhausted of air. When so exhausted, turn on the cock D to admit a little oxygen; this being an invisible gas, its presence will not be evident, until the cock C is also turned; the bladder, (and which must be perfectly dry) containing nitrous oxyde; this being admitted, will combine with the oxygen and form the gaseous acid required, which will be of a color more or less deep, according to the temperature.

787. Place in a tall jar a few grains of copper, silver, or tin, pour upon it a little dilute nitric acid, chemical action will soon take place, the nitric acid will be decomposed, a part of its oxygen uniting with the metal previous to its solution in that part of the nitric acid which is not decomposed, and the rest of the nitric acid which is decomposed, flying off in red or orange-colored fumes, which fill the vessel above the solution.

788. Tie a piece of loose tow, wool, or cotton, on the end of a small stick; damp it with water, and hold it for a few minutes in the red vapor. This, which before passed off into the apartment, will be in a great degree arrested and absorbed by the water, and taking from this oxygen, is converted into nitric acid, while nitrous oxyde escapes.

789. Try the last experiment with a perfectly dry piece of tow, wool, &c. The gaseous nitrous acid will not be absorbed so greatly as in the former instance, nor yet converted into nitric acid, but impregnate the wool with its own peculiar odour, and which will adhere to it for a considerable time.

790. Dip into the jar containing nitrous acid gas a piece of burning phosphorus, the flame will continue until the phosphorus is exhausted.

791. The same experiment may be tried with ignited charcoal with the same result.

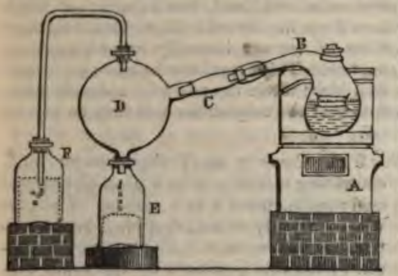
792. Try the above experiment with a taper, or with burning sulphur, and instead of the combustion continuing the ignited bodies will be extinguished.

793. An animal dropped into a jar of the gas instantly dies; even a small quantity of the fumes floating in the air of an apartment is highly injurious and suffocating.

794. *Nitric acid, aquafortis.* $(N+O_5=54.)$—The above equivalent supposes nitric acid to be perfectly dry, which it never is. The state we know it in is being united with water, therefore called sometimes liquid nitric acid, hydro-nitric, or aqueous nitric acid. It is extremely acid and caustic, and emits suffocating fumes when exposed to the air. It ought to be colorless, and of the specific gravity of 1·5; so that a pint weighs a pound and a half. It combines with numerous bases, forming the class of salts called

nitrates. It is often contaminated with nitrous gas, which occasions it to give off red fumes.

795. *To obtain nitric acid.*—Put into a retort any quantity of nitre, and pour upon it an equal weight of sulphuric acid, let the beak of the retort be attached to a receiver which has two other necks, one lengthened out like a funnel, and which after passing through a cork, is inserted into a bottle standing on a table, the other neck may have a glass tube fitted to it, the tube being so bent as to dip into a second bottle, as is altogether represented in the following cut, where B is the retort. C the connecting tube. D the receiver. E and F the bottles. Upon a fire being kindled beneath the retort at A, the nitre will be decomposed, and the acid distilling over will be absorbed by water placed in E and F; also in any other bottles which may be attached in a similar manner to the last and to each other.



796. *To obtain it on a large scale.*—"The manufacturer, who prepares aqua-fortis on a large scale, generally employs distillatory vessels of stone-ware. The following wood cut represents the arrangement of the distillatory apparatus employed at Apothecaries' Hall, for the production of common aqua-fortis. It consists of an iron pot, set in brick-work, over a fire-place; an earthen head is luted upon it, communicating with two or more receivers of the same material, furnished with earthenware stop-cocks; the last of which has a tube of safety dipping into a basin of water."—*Brande.*

797. *To purify nitric acid.*—Nitric acid procured by the above process is sufficiently pure for ordinary purposes; if it be required however for a test or other analytical purpose, it must be freed from the sulphuric and hydrochloric acid with which it will be contaminated. To do this first add to it a solution of nitrate of silver—this will separate the hydrochloric acid, the chloride of silver, a white insoluble salt, falling down. Then add the nitrate of baryta, which will precipitate sulphate of baryta, should the sulphuric acid be present. In either case, no more of the salts is to be added than just sufficient for the purpose; the quantity will therefore depend upon the degree of contamination. Upon pouring off the acid from the precipitate, and distilling it, it will be obtained perfectly pure.

798. *Is decomposed by light.*—Expose a bottle of colorless nitric acid to light; after some time it will assume a straw color, owing to a partial decomposition whereby nitrous acid is formed. By boiling this colored acid in a glass or earthenware vessel, this is expelled, and the nitric acid restored to its first colorless condition.

799. *Union with water produces heat.*—Mix nitric acid with water; the mixture will become quite hot, and the whole diminished in quantity. A tube similar to that of *Ex.* 60 may be used for this experiment.

800. *Union with ice produces cold.*—It is the case with this and other strong acids, and indeed with other bodies rapidly absorbent of water, that when added to pounded ice the latter is rapidly dissolved, and an intense degree of cold is thereby produced, as is always the effect of sudden evaporation or liquifaction. (See *Ex.* 26, 63, 64, and 65.)

801. *To decompose nitric acid.*—Pass the steam from boiling nitric acid, by an apparatus similar to that of *Ex.* 246, through a red-hot gun barrel. If the products be caught at the open end of the barrel they will be found to consist of nitrous acid, oxygen, and water.

802. Pour a few drops of nitric acid from a spoon tied to a long stick on to melted bismuth, the union of the two will be so quick that the metal will enter into a rapid combustion.

803. Perform a similar experiment with tin or zinc, or red-hot iron filings—these metals will in like manner be inflamed.

804. *Coloring of quills.*—Dip the quill part of a feather in nitric acid, and there let it remain from a second to five minutes, according to the strength of the acid. Upon taking it out little difference will be perceived, but upon exposure to light it will turn of a

bright and very durable yellow. It is advisable to wash the quill in water after being taken out of the acid. As nitric acid has the same effect upon the nails and skin, it must at all times be handled with caution.

805. *Coloring of woollen goods.*—Print any desired pattern on a piece of flannel or colored cloth, with nitric acid. After a little time wash away the superflous acid, lest it should corrode the woollen. This process will dye a permanent yellow color upon the flannel, and may be used as a marking ink for articles of this kind.

806. Drop a piece of glowing charcoal upon the surface of strong nitric acid, contained in a plate or saucer, and the combustion of the charcoal will be very greatly increased, bursting into an intense flame. This must be done with caution, lest particles of nitric or nitrous acid be scattered about.

807. *Disinfecting apartments by nitric acid.*—It has been already shown that the fumes of chlorine are exceedingly noxious and suffocating; therefore although chlorine is the best disinfectant, it cannot always be used, especially in the apartments of the sick. Owing to this, nitric acid is often employed for the same purpose, though not so effective. It may be made by adding saltpetre to sulphuric acid, contained in a saucer, and assisting the evolution of the gas by a gentle heat.

808. *Hyposulphurous acid.* ($S_2 + O_2 = 48.$)—This is a little known or used acid, forming the acid portion of the hyposulphites. It forms soluble salts with strontian and lime, in which respect it differs from the sulphurous and sulphuric acids, and forms a remarkably sweet-tasted salt, with chloride of silver. (See *Hyposulphites*, which salts are used as tests.) The acid in a free state cannot be procured without difficulty, and when procured by boiling sulphur in sulphurous acid, it is soon decomposed by exposure to the air, from which it absorbs oxygen, becoming sulphurous acid; also when zinc or iron are dissolved in a solution of sulphurous acid, they take part of the oxygen of the acid to themselves previous to solution. Two-thirds of the acid thereby becomes the hyposulphurous, which combines with half of the oxyde produced; while the other third, remaining as sulphurous acid, unites with the other moiety of the same oxyde. Thus dissolving zinc or iron in sulphurous acid, the salt obtained is of a mixed character.

Sulphurous acid. ($S + O_2 = 32.$)—This is a gaseous acid, readily absorbable by water. It may be procured in various ways, as by burning sulphur in oxygen, as in *Ex.* 220, also as follows:—

809. Put in a retort, the beak of which is small, 200 grains of mercury and 300 of sulphuric acid. Apply heat beneath the retort, the effect of which will be to decompose the sulphuric acid, a portion of the oxygen of which unites with the metals—the acid changing into the sulphurous.

To obtain sulphurous acid in a dry state, and to combine it with water, perform experiments with it analogous to 286 *and* 285.

To purify sulphurous acid. See *Ex.* 158.

810. *To liquify sulphurous acid gas.*—This is the easiest of all gases to liquify, requiring only a pressure of two atmospheres; the gas being at the freezing point. M. Bussy states, that it may be obtained in a liquid form, at common atmospheric pressure, by passing it through tubes surrounded by a freezing mixture of salt and snow.

811. *Ebullition of sulphurous acid.*—Put about a drachm of the liquid sulphurous acid upon ice-cold water in a wine glass. The sulphurous acid is instantly thrown into violent ebullition, and carries away so much heat from the ice-cold water, that numerous films of ice are instantly formed upon its surface. This experiment must be performed in a place where the powerful and suffocating fumes of the sulphurous acid may be carried off.

812. Cover a small thermometer bulb, containing mercury, with a piece of crape or thin muslin, place it in a current of air, or whirl it rapidly round, dropping liquid sulphurous acid upon it. The mercury is frozen by the cold produced by the rapid evaporation of the sulphurous acid.

813. *Does not support combustion or animal life.*—Into a jar of sulphurous acid gas immerse a lighted taper, and it will be instantly extinguished, as will also the life of an animal immersed in the gas.

814. *Bleaching with.*—Add a few drops of a blue coloured solution, made by boiling red cabbage leaves in water, to water in a wine glass, previously mixed with a little of the aqueous solution of sulphurous acid. The color is immediately discharged. See also *Ex.* 375.

815. Add in the next place a few drops of aqueous ammonia. The ammonia overcomes the action of the sulphurous acid, and produces a *green* compound with the coloring matter.

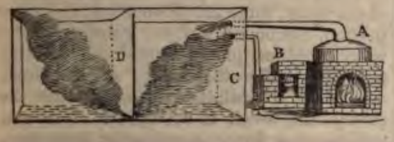
816. Add aqueous sulphuric acid diluted, drop by drop, till the ammonia is neutralized, and continue till the color becomes *red.* The sulphurous acid is now overcome by the excess of sulphuric acid.

817. Neutralize the sulphuric acid by ammonia, when the sulphurous acid again predominates, and the liquor becomes colorless.

818. *Hyposulphuric acid.* ($S2 + O5 = 72.$) This acid, which is intermediate between the sulphurous and sulphuric, is not procured free, except from its own salts, the hypo-sulphates, (which see.) Dr. Graham gives the following recipe to procure the acid from the hyposulphate of barium. He says, "The hyposulphate of barium may be evaporated to dryness, reduced to a fine powder, weighed and dissolved in water; for 100 parts of it 18.78 parts of oil of vitriol are taken, which, after dilution with 3 or 4 times as much water, are employed to decompose the salt of barytes. The liberated hyposulphuric acid solution is filtered and evaporated in vacuo over sulphuric acid, till it obtains a density of 1·347, which must not be exceeded, as the acid solution begins then to decompose spontaneously into sulphurous acid which escapes, and sulphuric acid which remains in the liquor.

819. *Sulphuric acid, vitriolic acid, oil of vitriol.* ($S + O3 + W.$)—This acid may be obtained in various ways. The first mode of preparation was from copperas or green vitriol, the sulphate of iron. Hence the name vitriolic acid. To show the method of procuring the acid from this substance; it is first to be dried by heat, until it falls into a powder, then distilled in a glass or earthenware retort. The first effect of heat upon the copperas is to cause an evolution of sulphurous acid gas, a portion of sulphuric acid being decomposed in converting the protoxyde of iron of that salt into the peroxyde. Vapors afterwards come over, which condense into a fuming liquid, generally of a black color, and of the gravity of about 1·9, which is the Nordhausen acid, and contains less than 1 equivalent of water to 2 of sulphuric acid. This acid is preferred for dissolving indigo and for some other purposes in the arts, and is the best source of anhydrous sulphuric acid.

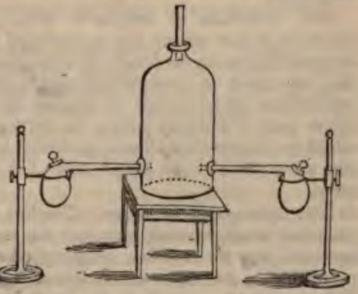
820. *To procure it from burning sulphur.*—The most abundant and ordinary source of sulphuric acid in this country is sulphur. It has been already stated, that burning this element in oxygen or in the air is productive of sulphurous acid; it is required to change this into sulphuric acid, by supplying it with a greater quantity of oxygen. For this purpose nitre is employed, this being decomposed by heat, affords parts of its oxygen to the sulphurous acid as required. On a large scale the following apparatus is used:—



A is a boiler or still to afford steam, wherewith the acid fumes may unite. B is a small furnace on the floor of which sulphur is strewed and set fire to, on this floor is a tripod stand supporting an iron capsule, which contains the materials for nitric acid, namely, sulphuric acid and either nitre or nitrate of soda. Both these furnaces open into a chamber lined with lead C, and this communicates with other similar chambers as D, all of them being also lined with lead. The heat of the burning sulphur evolves the nitric acid fumes, and consequently the sulphurous acid becomes mixed with nitric acid vapor, which it carries forward with it into the first chamber, when it meets with the steam, and the formation of sulphuric acid takes place. This condenses and trickles down the leaden walls on to the floor of the chamber, whence it is afterwards drawn off. It is necessary in the last chamber to have a pipe communicating with the outside, that uncondensible gases may be carried off. There must also be a slight draught through the chambers, because the acidifying principle is chiefly the oxygen of the apartment, and which after a time requires renewal.

821. *To purify sulphuric acid.*—The above, which is truly a hydrated sulphuric acid, and the ordinary colorless, oily liquid of the shops, is seldom pure, but contains traces of nitric acid and sulphate of lead. It may be purified by diluting it with water and then distilling it.

822. "The preparation of sulphuric acid may be illustrated very beautifully on a small scale, by making sulphurous acid and nitrous acid gases meet together in a glass vessel, and as the experiment is intended solely for illustration, the sulphurous acid gas may be prepared by the decomposition of sulphuric acid.



"Into one of the small retorts, (which should be large enough to hold about 3 or 4 ounces of water when full) put 400 grains of mercury, and 600 grains of sulphuric acid, and into the other 80 or 90 grains of sugar. Heat the first retort by a lamp, and when the sulphurous acid begins to come, pour over the sugar 300 grains of aqueous nitric acid, previously diluted with an equal bulk of water, and heat the retort gently till the nitrous acid fumes begin to come over, which are formed by the sugar attracting oxygen from the nitric acid. When then gases meet in the large bottle, a crystalline compound is soon deposited on the sides of the vessel in beautiful dendritical crystals, which often cover its whole interior surface. Remove the retorts when either the sulphurous or nitrous acid ceases to come over, and pour a little water into the bottle, a brisk effervescence immediately takes place when the water comes in contact with the crystalline compound, which is resolved into binoxyde of nitrogen, nitrous acid, and sulphuric acid; the former producing an additional quantity of ruddy vapors of nitrous acid, as it comes into contact with the air, and the latter being retained in combination with the water."—*Reid's Chemistry.*

823. *To concentrate sulphuric acid.*—This is done by distillation; a certain quantity of the acid is put into a retort capable of holding eight times as much,—this is connected with a *large* receiver, by a long and large glass tube which fits very loosely. A quantity of glass in small pieces is also put in the retort, and heat gradually applied beneath the retort. The water will first pass over, this may be thrown away, afterwards the sulphuric acid will distil, and as it does so frequent and sudden explosions of vapor take place, which with a fuller or smaller retort would burst the apparatus to the danger of the operator, resembling the exploson of gunpowder. Also in this distillation it is unnecessary to cool the receiver. If platinum foil or wire, or gold foil or wire, or pieces of flint be put into the retort along with the acid, it will prevent much of the irregularity of ebullition.

824. *Fixedness of sulphuric acid.*—By fixedness is here meant the property of not evaporating under ordinary circumstances. *Ex.* 245 shows its powerful action upon zinc, yet Bellani placed a piece of zinc foil in the upper part of a closed bottle, the bottom of which was covered with the concentrated acid, the metal retained its bright color for two years.

825. *Absorption of water.*—The last experiment would scarcely have had the result specified but for another property of sulphuric acid, its rapid absorption of water. In an atmosphere which is the least damp, zinc soon becomes tarnished, but in the above experiment, supposing the atmosphere of the bottle to be ever so much loaded with moisture, the sulphuric acid would absorb the whole of it, and afterwards not parting with it again, the zinc is kept perfectly dry. The powerful effect of sulphuric acid in absorbing moisture may also be tried in many other ways.

826. Dip a piece of sponge in water, wringing it out afterwards, so that it shall remain damp only, suspend this damp sponge in the upper part of a bottle, which holds a little strong sulphuric acid. The acid will attract water from the sponge so rapidly that it will soon become dry while the acid will be increased in quantity, in proportion to the quantity of water at first adhering to the sponge.

827. Weigh 3 ounces of strong sulphuric acid, pour it into a saucer, and leave it exposed to a damp atmosphere for 24 hours, at the end of that time, the 3 ounces will have increased to nearly 4 on account of the water absorbed from the atmosphere.

828. *Drying of gases.*—The last experiment suggests a method of drying gases by the aid of sulphuric acid, particularly chlorine. It may be readily performed as follows:—Fill a jar with the acquired gas, and suspend in it a watch-glass, or small saucer, (according to the quantity of gas) half-full of strong sulphuric acid, this will in an hour or two, as in a former experiment, absorb the surrounding moisture and leave the gas perfectly dry. It may be advisable sometimes to use a large quantity of the acid, and to immerse the jar of gas wholly in the acid,

Nos. 60, 62, 65, 149, 341, 342, and 362, are also experiments of sulphuric acid.

829. *Anhydrous sulphuric acid.*—In making dark colored acid of *Ex.* 819, a portion of it often congeals into a mass of crystals; this is anhydrous sulphuric acid. It may be procured at all times by distilling this dark acid, keeping the receiver at the same time cool. It may also be obtained by heating the sulphate of antimony gradually to redness in a green glass retort, the receiver being kept very cool. This is an article of curiosity rather than utility.

Hydrosulphuric acid, or *sulphuretted hydrogen.* See *Gases.*

The acid compounds of oxygen and phosphorus are the hypophosphorous, the phosphorous, the phosphoric, the pyrophosphoric and the metaphosphoric acids. The two last are mere modifications of the phosphoric acid.

830. *To procure hypophosphorous acid.* ($\mathrm{Ph}\,2+\mathrm{O}=40$.)—Upon 1 part of phosphuret of barium pour 4 parts of water, of which the phosphorus of one portion oxidates and becomes the acid in question, at the expense of the water, while the phosphorus of another portion, combining with the hydrogen of the water, produces phosphuretted gas. Let this gas escape, filter the liquor, add sulphuric acid while a precipitate falls, separate the precipitate, which is a sulphate of baryta, and the clear liquor contains the hypophos-

phorous acid. It may be concentrated by evaporation, but does not crystallize.

831. *To procure phosphorous acid.* ($Ph + O\,1\frac{1}{2} = 28.$)—This is not procured in a dry state without difficulty; the process of Sir H. Davy is considered the best, it is as follows:—"A piece of dry phosphorus is put into a retort formed of a tube of glass, and bichloride of mercury in powder placed over it. On exposing the retort to heat, the phosphorus as it rises in vapor through the bichloride, takes one proportion of chlorine from it, and a limpid fluid condenses in the receiver, a compound of chlorine and phosphorous. On mixing it with water, this is decomposed, the chlorine uniting with a portion of the hydrogen of the water, forming hydrochloric acid, while the phosphorous takes the oxygen, and is converted into phosphorous acid. By heating the liquid the hydrochloric acid and most of the water are driven off, and the phosphorus acid, still combined with a portion of water remains. On cooling it becomes a solid crystalline mass.

832. *Second method.*—Heat a long glass-tube, closed at the lower end, and with a fine orifice only at the upper, so as to expel a great portion of the air, but do not make it so hot as to burn the hand applied to the outside; drop into it a small piece of phosphorus, and if it does not take fire hold the lower end over a lamp, or still better dip it into hot water to inflame the phosphorus. This will burn away very gradually, and combining with the limited quantity of oxygen in the tube, will be converted into dry phosphorous acid, which will congeal as a white substance in the upper part of the tube. When exposed to moisture or to the air, it soon changes into phosphoric acid.

833. *To procure phosphoric acid,* ($Ph + O\,2\frac{1}{2} = 36$;) also, *pyrophosphoric* and *metaphosphoric acids.*—Place a piece of phosphorus on three or four penny pieces piled up in the middle of an earthenware plate, set fire to it, and cover it over with a large glass jar. The phosphorus as it burns away will combine with the oxygen of the air within the jar, and form a copious flocculent white powder, which, if the jar and plate be perfectly dry, will adhere to the sides of the former. This is called *glacial phosphoric acid,* or metaphosphoric acid. If the plate have a little water previously poured into it, the solid acid will rapidly combine with the water, and form the liquid *phosphoric* acid. If glacial phosphoric acid be retained at a red heat for some time, its properties are somewhat altered, and it becomes pyrophosphoric acid, but returns to the state of the liquid acid when boiled with water.

834. Collect the dry phosphoric acid of the last experiment; put it quickly into a dry watch glass, and add to it a few drops of water. The solution of the acid will be so rapid, that a hissing noise and great heat will be occasioned, and sometimes even a violent explosion will accompany the action. *Note.*—Phosphoric acid is not poisonous, nor yet does it corrode the skin, but it is intensely sour in taste. It forms the salts called *phosphates.*

Carbonic acid. See *Gases.*

835. *Boracic acid.* ($Bo + O\,6 = 68.$)—This is the only known compound of oxygen and boron; it is very easily procured from the common salt called *borax*, which is the borate of soda, formerly called *sedative salt.* Dissolve any quantity of borax in four times its weight of boiling water, and add half its weight of sulphuric acid. This by abstracting and uniting with the soda forms the sulphate of soda, and leaves the boracic acid as a white scaly precipitate. This, exposed to a strong red heat to expel any traces of water and sulphuric acid remaining, constitutes the pure boracic acid, in the state of a hard transparent glass. It may be pounded, or else re-dissolved and re-crystallized, and kept for use in a phial.

836. Dissolve a little boracic acid in alcohol, set fire to the latter, and in consequence of the presence of the boracic acid, the flame will be of a fine green color.

837. Add a little boracic acid to a solution of turmeric in a wine glass; it will turn it of a *brown* color—a curious circumstance, inasmuch as this is the property of an alkali, and is not the effect of acids in general.

838. Add a little boracic acid to a solution of litmus, and it will turn it of a brownish red, like the color of port wine; but not of that clear red which other acids occasion.

839. *Manganesic acid. Manganic acid.* ($Man + O\,2\frac{1}{2} = 48.$)—Put into a crucible, large enough to hold three times the quantity, 1 part of the black or peroxyde of manganese, intimately mixed with 3 or 4 of nitre. Expose this mixture to a red heat for half an hour; during this process the nitric acid of the nitre is completely decomposed, part of its oxyde combining with the binoxyde to form manganesic acid, which uniting with the potass of the nitre forms the manganesate of potass—this is a salt of a green color, and very deliquescent; it must therefore be kept in a well-corked bottle.

840. It may be obtained without the decomposition of nitric acid, by fusing together caustic potass and the peroxyde of manganese—a green mass of the manganesate of potass is hereby obtained. This salt has very peculiar properties. (See *Manganesic Salts.*)

The acid cannot be abstracted from the alkali in an isolated form, as unless combined with alkali, and even an excess of alkali, it becomes decomposed.

841. Dr. Gregory recommends the following process as preferable:—Mix intimately 4 parts of peroxyde of manganese in fine powder, with $3\frac{1}{2}$ parts of chlorate of potass, and add them to 5 parts of the hydrate of potass, dissolved in a small quantity of water. Evaporate the mixture to dryness, then powder it, and afterwards let it be ignited in a platinum crucible, at a low red heat, but not fused. When digested in a small quantity of cold water, this affords a deep green solution of the alkaline manganesate, which may be obtained in crystals of the same color, by evaporating the solution over sulphuric acid in the air pump.

842. *Antimonious acid, deutoxyde of antimony.* ($\mathrm{Ant}+\mathrm{O}\,2=81.$)—Heat in a crucible open to the air any quantity of the protoxyde of antimony, (*Ex.* 683;) it absorbs more oxygen and becomes antimonious acid. It is only known as an acid by its reddening the solutions of blue coloring matters.

843. *Antimonic acid, peroxyde of antimony.* ($\mathrm{Ant}+\mathrm{O}\,2\frac{1}{2}=85.$)—Make a mixture of 4 parts nitre and 1 of metallic antimony. Put the mixture into a crucible, and let it burn away; the residue is then to be washed in nitric acid and water; a white or straw-colored powder of antimonic acid will fall down.

844. *Second method.*—Dissolve antimony in aqua regia, and pour the solution in water, by this means the solution will be decomposed, and the antimony already partly oxydated previous to its solution in the acid, becomes more so, and changes into the antimonic acid, which is immediately precipitated.

845. *Third method.*—Add metallic antimony to fine powder, or the protoxyde of this metal to hot nitric acid, in a green glass flask or evaporating basin, evaporating to dryness, and heating what remains to a temperature of 500° or 600° to expel any water which it may still contain.

846. *The selenic, uranic, titanic, telluric, molybdic, vanadic, tungstic, and columbic acids*, obtained by the union of oxygen with the metals of corresponding names, having no place in the processes of the arts, nor yet being used in medicine, are here disregarded as to make them involves much trouble, and answers no purpose of general utility.

847. *Chromic acid, peroxyde of chromium.* ($\mathrm{Chr}+\mathrm{O}\,3=52.$)—This acid of which the salts (called chromates) are so valuable as chemical tests and as pigments, is of a dark red color, (almost black when heated,) sour and metallic, soluble in water, and alcohol. To procure the acid, mix 4 parts of chrome yellow, (chromate of lead) with 3 of finely powdered fluor spar, previously heated to redness, and 5 of strong sulphuric acid, heat this in a *leaden* or silver retort, when a red vapor will be liberated; this is the fluoride of chromium, which by adding water is decomposed into hydro-fluoric and chromic acids; by evaporating the solution by a gentle heat, the former acid flies off, and the chromic acid is retained pure.

848. Instead of receiving the red vapor into water, let it strike against a sheet of blotting paper, loosely crumpled by the hand into a ball, the vapor will be decomposed as before, and the chromic acid obtained in dry crystals instead of in the state of a solution as in the last experiment.

849. *Arsenious acid, white arsenic, white oxyde of arsenic.* ($\mathrm{Ar}+\mathrm{O}\,1\frac{1}{2}=50.$)—This the most important compound of arsenic occurs native, and is also manufactured, being usually prepared by roasting the arseniuret of cobalt in a reverberatory furnace; when the arsenic is sublimed and oxydated, condensing in cakes in the chimney of the furnace. It is sublimed a second time in iron vessels, and then forms the common *arsenic* or white arsenic of the shops, it being usually powdered previous to sale. The taste is not acid, but on the contrary, slightly sweet. It is soluble in about 400 times its weight of cold water, and about 13 times of boiling water; this retains however when afterwards cooled as much as about a 30th part of the acid. It is soluble in about 80 parts of alcohol at 60°. It is also dissolved by several of the acids and oils.

For numerous experiments with this highly poisonous substance, see *Tests.*

850. *Arsenic acid.* ($\mathrm{Ar}+\mathrm{O}\,2\frac{1}{2}=50.$)—Put into a retort arsenious acid, or else metallic arsenic, and pour over it strong nitric acid; apply a gentle heat, when the nitric acid will be decomposed—a part of its oxygen uniting to the arsenious, and forming the arsenic acid. The solution must be afterwards evaporated to dryness in order to obtain the acid, which is white, non-crystalline, of a sour taste, and deliquescent. It is soluble in 6 parts of cold and 2 of boiling water.

851. *Scheele's method.*—Dissolve 3 parts of arsenious acid in 7 of hydrochloric acid by the assistance of heat; after which 5 parts of nitric acid are to be added, and the liquid evaporated to dryness, the residue may then be heated to dull redness in a crucible. Bucholz recommends 2 parts of hydrochloric acid, 8 of arsenious acid, and 24 of nitric acid. Its salts are *arseniates.*

BINARY ACIDS WITHOUT OXYGEN.

It has been already stated, (p. 99,) that oxygen is not the only acidifying principle, chlorine in some cases giving to other elements an acid character, and still more often hydrogen having the same effect. From the combination of these two elements, we derive the powerful acid, the hydrochloric. Other combinations of hydrogen give the hydriodic, hydrobromic, hydrofluoric, and the hydrosulphuric acids, (the last commonly called sulphuretted hydrogen, is for convenience discussed along with other gases.) So also the chloric acids are united together under the next article, (*Chlorides.*)

Ex. 852. *Hydrochloric acid. Muriatic acid.* $(H+C=37.)$—Mix together in a jar equal measures of chlorine gas and hydrogen; expose the mixture to light, when the gases will unite, and form the hydrochloric acid in a gaseous state, and without water.

853. If the above be exposed to the direct rays of a hot sun, the gases will ordinarily combine with such rapidity as to explode with violence.

854. Procure a tube 12 inches long, of ½ an inch internal diameter, fill it with the mixed gases, and expose it to a full light, the combination of the gases will almost instantly be seen to commence by the cloudy appearance produced within the tube; now cover over the tube, and the action will cease until a second time exposed, and thus by repeating the experiment, the action of light upon the gases is beautifully shown, while from the small size of the tube, there is no danger of submitting the whole to the direct rays of the sun.

855. Mix chlorine and hydrogen together, the exact proportions of each is of little consequence, though the effect is greatest when in equal quantities. Fill a jar or phial with this mixture, and quickly insert a lighted match, the gases will explode with a loud report, though if the jar have an open mouth and be tolerably thick, without danger. The least increase of heat, even the smallest spark struck with flint and steel will inflame the gases, so will also the smallest electrical spark, and very often agitation. Thus lecturers and others should never mix the gases previous to use, as we once knew a jar thus filled, explode from standing too near to and becoming heated by a spirit lamp, and the explosion took place not from the rarefaction by heat bursting the glass, but from the combination of the gases themselves. Also a mixture of these gases, though answering the same purpose as oxygen and hydrogen in the compound blowpipe, are still more dangerous to operate with.

856. Perform *Ex.* 259 with chlorine instead of oxygen, the result will be the same for a time, but hydrochloric gas being formed, this will soon fill the larger tube, and being a non-supporter of combustion, will impede the continued action of the apparatus.

857. Previous to the inflammation of the gases in *Ex.* 853, pour into the bottle containing them a little weak solution of red cabbage or of litmus—this is of a blue color, but the chlorine present in the bottle will render it colorless. Take a second jar or bottle, filled in like manner; explode the gases, and then pour into it the colored solution—instead of being deprived of its color as before, it will be rendered red, showing that an acid is present.

858. Take a bottle in which the gases have just been exploded, and turn it mouth downwards in a saucer or basin of water. The hydrochloric gas with which it is filled will be so rapidly absorbed by the water, that the latter will rush up the bottle, until it is entirely filled with water, which during the absorption becomes more and more acid in character; it is, in fact, now a dilute hydrochloric acid. If the quantity of gas be large, and that of the water small, considerable heat will be given out, so that the liquid acid will be quite warm.

859. *To procure hydrochloric acid gas.*—To obtain the gas in a dry state for the purpose of experiment, the converse of the last experiment may be performed, by putting some liquid hydrochloric acid, or spirits of salts as it is often called, into a retort, applying a spirit lamp beneath, and catching the gas which rises in a flask, as advised in *Ex.* 327.

860. *To procure hydrochloric gas: Second method.*—Put common table salt into a flask, as in *Ex.* 327, and pour upon it dilute sulphuric acid, sufficient to cover the salt—the retort being when this is added about a quarter full. A decomposition immediately takes place, the sulphuric acid seizes upon the soda of the salt, and suffers the hydrochloric acid to escape in fumes. Placed in a retort it may be condensed in water, using a series of Woolfe's bottles, as in *Ex.* 285. The salt should be pounded and made red-hot before use, in order to drive off any nitrate mixed with it. For the reason of pounding it, see *Ex.* 38.

861. *Third method.*—Instead of salt, use sal ammoniac, which is a combination of ammonia and hydrochloric acid. The result will be similar to the last experiment—the required acid being liberated copiously.

862. *To liquify hydrochloric acid gas.*—Put the ingredients for making the gas into one end of a tube, shaped like that of *Ex.*

283. Let the gas be liberated, and when the violence of the action begins to subside, melt in a blow-pipe the opposite end of the tube, so as effectually to close it. As the greater part of the gas will have passed off during the first violent ebullition, and before the tube is closed, it is requisite to apply the heat of a spirit lamp beneath the filled end, to liberate a further supply of the gas. When the pressure within the tube amounts to about 40 atmospheres the gas will be liquified. The tube must be very strong, and should at all times of making the experiment be covered with a wire guard. In fact, the greater part of the tube may have strong string or wire twisted round it.

863. *To purify hydrochloric acid.*—The acid usually procured is contaminated with sulphuric acid and sulphurous acid, which occasions it to be of a yellow color, (bromine may have the same effect.) To purify the acid, first add the chloride of barium, (muriate of barytes,) while a precipitate falls down. This will discover and separate the sulphuric acid. Then add a few crystals of the protochloride of tin, which salt decomposes sulphurous acid, and occasions after standing some time a brown precipitate of sulphuret of tin. These precipitates being removed, the purified acid may be poured off, and redistilled along with an equal weight of water.

864. *Condenses the moisture of the air.*—Suffer the fumes of common hydrochloric acid to escape into the air; as they issue from the throat of the bottle which contains the acid they are colorless, but when further escaped they assume a white color, in consequence of condensing the moisture of the air.

Union of hydrochloric acid gas and ammonia. See *Ex.* 16.

865. Pour some strong hydrochloric acid upon some pieces of zinc in a bottle, a violent action will take place, and a rapid escape of hydrogen gas which may be inflamed as in *Ex.* 244.

866. Pour some strong hydrochloric acid upon some of the peroxyde of lead, or of manganese, the acid will be decomposed and *chlorine* be given off.

867. *To try the strength of hydrochloric acid.*—Take any quantity of hydrochloric acid, dilute it with an equal weight of water, and drop into it fragments of marble, taken from a quantity previously weighed till it will not dissolve any more. Then ascertain the quantity of marble dissolved, by weighing what is left. Then calculate the quantity of pure dry acid by allowing 36½ grains of dry acid for every 50½ of grains of marble dissolved.

868. *Does not support flame, or animal life.*—Perform *Ex.* 333 with hydrochloric acid gas, the result will be the same, the flame will be extinguished, the animal will die.

869. *Hydriodic acid.* ($H + I = 126.$)—This like the last is a gaseous acid, absorbable by water, sour to the taste, reddens vegetable blue colors, is deadly when respired, extinguishes flame, &c. It may be procured thus:—

870. Pass hydrogen gas together with the vapor of iodine, through a red-hot tube, they will combine and form hydriodic acid.

871. Take a small stoppered retort or bent tube, and into the body of it put iodine moistened with water, fix the beak of it to a gas jar standing over mercury, or to a dry bag or bladder, and when so fixed, drop by little at a time phosphorus to about the weight of a 12th part of the iodine, a rapid decomposition will ensue, and hydriodic acid be liberated. The action is generally very rapid.

872. *To procure the liquid acid.*—Pass a stream of sulphuretted hydrogen through a solution of iodine and water, sulphur is deposited, and on heating and filtering the liquor, a pure solution of hydriodic acid is obtained, and which may be concentrated by evaporation.

873. *Second method.*—Dissolve the iodide of starch in water, and pass through the water some sulphuretted hydrogen, till the liquid becomes white. Then filter the liquor and boil it for a short time, the acid will be formed. In this process the hydrogen of the sulphuretted hydrogen combines with the iodine of the iodate of starch, and forms the hydriodic acid, which remains in solution, while the sulphur and starch being insoluble are separated. The mixture passes through a variety of shades of color from the deep blue of the iodine to a rich brownish red, orange, and yellow color, before it becomes ultimately white. These changes succeed each other rapidly, and present a very beautiful appearance when the sulphuretted hydrogen is rapidly evolved.

874. *Decomposition of.*—Mix together 10 drops of nitric acid, and 10 drops of nitrous acid, both strong; fill a small open-topped phial, holding not more than 2 ounces with dry hydriodic acid, and pour into it the mixed acids. The hydrogen of the hydriodic acid immediately combines with the oxygen of the nitric acid, and the iodine is set at liberty, the mixture often inflames, even when the experiment is performed with the above small quantity.

875. Suffer a very minute stream of chlorine gas to issue into a small jar of hydriodic

acid. The chlorine immediately unites with the hydrogen of the acid, forming the hydrochloric acid gas, purple colored vapors of iodine appear and speedily condense, and if much chlorine be brought at once in contact with the acid gas, an explosion ensues, and a flash of light is at the same time perceived; 3 or 4 cubic inches of hydriodic acid are enough for this experiment. The blue vapor of the iodine soon disappears in consequence of its uniting with chlorine, and forming the chloride of iodine.

876. The above experiment may be varied, as follows:—Fill a jar with atmospheric air; mix with this a twelfth part of chlorine gas—then admit a small stream of hydriodic acid gas—the effect will be very apparent, and the blue vapor of iodine seen.

877. *Hydrobromic acid.* ($H+B=76$.) Perform *Ex.* 870 with bromine instead of iodine, and hydrobromic acid will be formed.

878. *Second method.*—To the bromide of potassium add dilute sulphuric acid; assisted by a gentle heat a decomposition takes place, the result being a sulphate of potass and hydrobromic acid—the oxygen of the water uniting with potassium to form potass, and its hydrogen uniting with bromine to form the hydrobromic acid. This acid much resembles in properties that last described, and also hydrochloric acid. It may be collected over mercury or in dry phials, and is rapidly absorbed by water.

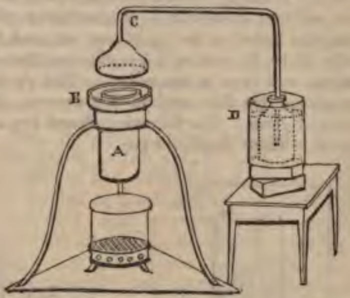
879. Pass a stream of chlorine through a solution of hydrobromic acid, and the latter will be completely decomposed, resolving itself into vapor and drops of bromine; if a little liquid be in contact with the hydrobromic acid, the bromine will be absorbed, forming the bromide of mercury, and hydrochloric acid occupying the vessel. The hydrochloric acid is not affected by mercury; it is therefore the chlorine only which occasions the above decompositions.

880. Iodine vapor and oxygen, separate or together, occasion no change to the solution of hydrobromic acid, when made to pass through it.

881. Into a jar of hydrobromic acid gas, drop a small piece of potassium. The gas will be decomposed, and its bromide uniting with potassium forms the bromide of that metal—hydrogen is given off.

882. Mix together equal parts of hydrobromic acid and nitrid acid. A decomposition of both takes place, with the formation of nitrous acid and water, and the evolution of bromine. While this decomposition is going on, if gold leaf be added it will be dissolved.

883. *Hydro-fluoric acid,* commonly called *fluoric acid.* ($H+F=19$.)—This of all substances is the most corrosive, the least quantity touching the skin occasions deep and painful sores—its vapor is most irritating to the eyes and oppressive to respiration. It is the only liquid which dissolves flint and glass, therefore cannot be kept in a glass vessel. Leaden, silver, gold, or platinum vessels must be used to confine it, and even these must not be soldered with solder made of tin, as it rapidly dissolves that metal. The apparatus in which it is made must be also of one of the above metals. Neither the acid itself nor its combinations are valuable, its chief use being in etching upon glass. Dr. Reid recommends a leaden apparatus of the following character for the formation of this acid:—



A is a deep leaden cup, with a rim of lead fastened round the top, a small space being left between it and the cup, for fixing the head of the apparatus, when the materials have been put in. The easiest way is to fill this intervening space with plaster of Paris, and put in the cover before it begins to set, taking care to have the tube C and bottle receiver D previously properly adjusted. The receiver is placed in a jar or basin, and surrounded with ice or very cold water; if the acid is to be procured in a liquid state, the bottle must contain water to absorb the hydrofluoric acid gas.

884. *To procure hydrofluoric acid.*—Put into the leaden cup of the former apparatus some Derbyshire spar, (which is the fluate of lime,) reduced to a fine powder; to this add its own weight of sulphuric acid. Immediately fasten down the cover, and apply the heat of a small furnace or strong lamp beneath the cup. This will liberate the gas, and which previously had formed the acid part of the fluate.

885. *Etching on glass by fluoric acid, showing the strong affinity of fluoric acid for silica.*—Procure several clear pieces of crown glass, and immerse them in melted wax, so that each may receive a complete coating. When perfectly cold, draw on them with a fine steel point, flowers, trees, houses,

portraits, letters, &c. Whatever parts of the drawing are intended to be corroded by the acid should be perfectly free from the least particle of wax. When all these drawings are finished, the pieces of glass must be immersed one by one in a square leaden box or receiver, where they are to be submitted to the action of fluoric acid, either in a liquid or a gaseous state. It will be necessary in the latter case to have some water in the receiver, for the absorption of the superabundant gas, and the receiver should have a short leaden pipe attached to it for the reception of the beak of the retort; this should be well luted with wax. At the top of the receiver there is a sliding door for the reception of the plates; this is to be well luted while the gas is being formed. When the glasses are sufficiently corroded, they are to be taken out, the operator having gloves on, and the wax is to be removed by dipping them in warm, and then in hot water. The devices produced by this method are opaque, like ground glass. The following shows the apparatus above described:—

A is the lamp. B the leaden retort. C the leaden receiver for the reception of the plates of glass. D D two pieces of glass suspended within the receiver. E a perforated bottom to the receiver, to distribute the gas equally throughout.

886. *To etch by the liquid acid.*—Glass may also be etched by immersing it in the liquid acid, after having been coated with wax, and drawn upon as in the last experiment. The result of thus using the liquid acid is, that the figures will be equally transparent as the rest of the glass.

887. Methods easier than the former are as follows:—Put the requisite ingredients into an evaporating basin, cover it over with the sheet of glass, previously waxed and etched, and apply heat beneath. The fumes will soon rise, and corrode the glass.

888. Having the sheet of glass prepared as before, surround it with a raised edge of wax—pour upon the surface, so as to cover the whole of it, some dilute hydrofluoric acid, being careful not to imbibe the fumes, the glass will be corroded wherever the acid is allowed to penetrate.

889. Dust the sheet of glass, previously waxed, over with finely powdered Derbyshire spar. Then pour upon it a little sulphuric acid, taking care not to disturb the powder. The decomposition will take place as before, and the glass be corroded; part of the gas flying off, as may be known by a second sheet of prepared glass being placed over the first, and another portion of gas being retained in the liquid; it is this which occasions the corrosion. If a thermometer tube or other similar shaped body be etched, it may be dipped in sulphuric acid, and then dusted over with the powder.

Hydrothionic acid. See *Sulphuretted Hydrogen among the Gases.*

CHLORIDES.

These are combinations of chlorine with other bodies, metallic and non-metallic. Some of them have been already explained under the words protoxyde and peroxyde of chlorine and chloric acid, all compounds of this element with oxygen; hydrochloric acid, or chlorine and hydrogen, &c. The following are other important compounds of this element; many of them it will be seen are of an acid character, showing that chlorine, no less than oxygen, is sometimes the cause of acidity.

Ex. 890. *Chloride of iodine. Chloriodic acid.*—When chlorine is conducted into a vessel containing iodine, it is quickly absorbed, and a compound obtained, which is brown when the iodine is in excess; colorless when exactly saturated; and yellow if there be excess of chlorine. It is volatile, sour, reddens litmus, attracts moisture, and dissolves in water. According to the quantity of chlorine which enters into the composition, the result is either the ***protochloride***, which is $C + I = 161$, or the perchloride which contains double the former quantity of chlorine, or $2C + I = 197$. The first is called sometimes the ***chlorionic*** acid, and contains an excess of iodine. The latter or peroxyde being the saturated compound or chloriodic acid.

891. *Chloride of bromine.*—Pass a stream of chlorine gas through bromine, condensing the vapors by ice or cold water, the chloride of bromine will be formed. It is a reddish-yellow fluid, volatile, of a disagreeable odour and taste, soluble in water, and destroying vegetable colors.

892. *Chloride of nitrogen,* ($N + Ch\ 3 = 122$,) or ***chloride of azote***. This is one of the most explosive and dangerous compounds

known to the chemist; all its experiments must be conducted with the greatest caution. It is an oil-like fluid, heavier than water, of penetrating odour, not congealed by cold, and exploding at a heat less than that of boiling water. A drop the size of a very small mustard seed is all that must be operated upon at once.

888. *To prepare chloride of nitrogen.*—Prepare a solution of nitrate of ammonia in a clean jar, so that about one half shall be filled; let this solution be as cold as possible, or at least not above 40° of heat. Now pass into the jar some chlorine gas from a retort containing 1 ounce of oxyde of manganese and 2 ounces of hydrochloric acid. The gas will be absorbed almost as rapidly as it ascends, and presently the top of the solution will be covered by a film, which collecting into yellow globules will fall to the bottom. This is the chloride of nitrogen, and for the sake of experiment is most conveniently and safely removed by a syringe, made of a piece of glass tube, of the following form:—the piston of it is a piece of copper wire, with a little clean tow wrapped round it, in this way a globule may be drawn into the tube and transferred to any other vessel. Great care must be taken not to oil or grease any part of the tube or piston.

889. *Explosion by heat.*—Put a particle of chloride of nitrogen, of the size of a pin's head into an iron spoon, tied to the end of a stick a yard or more in length; hold the spoon over a lamp or fire for a few seconds, the chloride will explode with a very loud report.

890. *Explosion with the contact of oil.*—Put a minute quantity of the chloride on a plate of iron, or a large stone, dip the end of a long stick in olive oil, and touch the chloride with the oily end; the instant contact takes place, a loud explosion ensues, often with the fracture of any fragile article standing near, so great is the concussion of the air.

891. The same may be tried with tallow, any essential oil, spirits of turpentine, naphtha, palm oil, whale oil, ambergris, or strong liquid ammonia.

892. If half a grain of chloride of nitrogen be put gently on a sheet of writing paper, and a grain of phosphorus, stuck to the sharpened end of a wire about two yards long, be brought in contact with it, a most violent explosion will instantly take place. This experiment wounded Sir H. Davy and occasioned Dulong the French chemist the loss of an eye and a finger. It requires a mask to the face, because of the dispersion of the phosphorus. It should also be performed in the open air. When a soup plate was taken to hold the chloride, though a quantity was used not larger than a mustard seed, the detonation was so great as to shatter the plate into a thousand pieces.

893. Moisten the end of a wire with the chloride, and with the moist end touch a lump of fused potass, or a piece of phosphoret of lime, or else dip it into a jar of phosphuretted hydrogen, explosion will in each instance take place.

894. *Protochloride of sulphur*, $(\mathrm{S} + \mathrm{C} = 52,)$ is an irritating and fuming yellow liquid, absorbable by water. It may be procured by passing a stream of chlorine through a tube containing powdered sulphur, also by burning sulphur in a jar of chlorine gas.

895. *Protochloride or sesquichloride of phosphorus.* $(\mathrm{Ph} + \mathrm{C}\ 1\frac{1}{2} = 70.)$—"Distil phosphorus and perchloride of mercury. It is also formed by passing chlorine first through a cold flask, then through a tube containing fragments of chloride of calcium (muriate of lime,) and thence into a tubulated retort slightly warmed, and containing phosphorus, from which the sesquichloride, as it is formed, gradually distils over into a cooled receiver."—*Gmelin.*

896. *Perchloride of phosphorus.* $(\mathrm{Ph} + \mathrm{C}\ 2\frac{1}{2} = 106.)$—If a stream of chlorine be passed through the above compound, it will absorb another atom of chlorine, and be converted into the perchloride. It may also be obtained by burning phosphorus in excess of chlorine.

897. *Chloride of selenium*, $(\mathrm{Se} + \mathrm{C}\ 2 = 112,)$ and *perchloride of selenium* $(\mathrm{Se} + \mathrm{C}\ 3 = 148,)$ are procured by methods similar to those of phosphorus.

Chloride of boron. See *Ex.* 299.

Chloride of carbon. See *Ex.* 297.

898. *Chlorides of the metals.*—The whole of the metals unite with chlorine, forming metallic chlorides. Many of them with such energy that the metal is inflamed, thus it is with potassium, sodium, gold, silver, tin, bismuth, &c., as was shown in the *Ex.* 300 to 310, and which experiments may be made with other metals in like manner, and with the same result. A second, as a more easy method of forming a chloride, is to add hydrochloric acid to a neutral, alkaline, or earthy metallic oxyde, or by decomposing by the same acids some of their salts. By this means a class of compounds formerly called *muriates* is obtained. The constitution

of such muriates was but little understood till recent research occasioned the changes that take place to be appreciated. For example, *muriate of potass*, was thought to be a salt consisting of the muriatic acid, (now hydrochloric acid) and potass, and considering that the acid is composed of hydrogen and chlorine, and the alkali of oxygen and potassium, the salt was thought to be a union of these four elements. This is however not the case, upon blending together the hydrochloric acid and an oxyde, a decomposition of both takes place, and two new compounds are formed—the hydrogen of the acid unites with the oxygen of the base, and forms water, the chlorine of the acid joins itself to the metallic part of the base, and forms a chloride of that metal, and which chloride is of course a binary substance. We shall mention below only a few of the metallic chlorides, choosing such for illustration as are most important in the arts, or which present some peculiarities. When oxygen in excess is combined with such chlorides, they become first *perchlorides*, and with a still more abundant dose of oxygen, *chlorates*. If the hydrochloric acid or the base be not decomposed when uniting together, *hydrochlorates* are produced, as the hydrochlorate of ammonia.

899. *Chloride of potassium. Muriate of potass.* ($P + C = 76.$)—The combination of potassium and chlorine is commonly made by dissolving potass in strong hydrochloric acid to saturation; then evaporating the moisture, and heating the residuum to redness.

900. For the sake of experiment it may be made by burning potassium in chlorine gas, as in *Ex.* 301 ; or by adding potassium to the chloride of sulphur, when the latter will be decomposed with very rapid and beautiful combustion, or in most cases with explosion. The result is the chloride of potassium and sulphur.

901. *Freezing mixture with.*—Add 1 oz. of the powdered chloride of potassium to 4 oz. of water; stir them together, and a great degree of cold is produced, equal to about 25°, or 8 times as great a reduction as with common salt.

902. *Chloride of sodium, common salt, muriate of soda.* ($So + C = 60.$)—To manufacture common salt is scarcely necessary to be described, so extensively is it found in sea-water, in salt mines, and in marine productions. A concise account of the different modes of manufacture will be found in Aikin's "Dictionary of Chemistry." The common salt obtained from these sources is sufficiently pure for ordinary purposes, but as it generally contains the chlorides of magnesium and of calcium, it must be purified when required as a chemical test, or made either by *Ex.* 302, or else by adding the hydrochloric acid to pure soda. When thus procured it is not affected by the air, not becoming damp, when exposed to a damp atmosphere.

Mixture of salt and snow, effects of. See *Ex.* 26.

Decrepitation of sea-salt. Ex. 38.

Solubility of salt. Ex. 73.

To separate from plaster of Paris. Ex. 88.

Crystallization of salt. Ex. 182.

Decomposition of from soda. Ex. 737.

903. *Chloride of calcium,* ($Cal + C = 56$) *muriate of lime, bleaching powder.*—Dissolve chalk, or carbonate of lime in hydrochloric acid, evaporate to dryness, and reduce the dry mass to a red heat in a crucible. It must be kept in well-closed stoppered phials, as it is the most deliquescent substance known, for which purpose it is used for drying gases and other purposes in chemistry, and especially as a bleaching powder. See *Ex.* 286.

904. *To concentrate alcohol.*—It has been recommended to add this substance to spirits of wine, in order that the water attached to the spirit may be absorbed. It is however highly improper for that purpose, for the chloride of calcium dissolves in the alcohol, and thus if so much be added as to remain as a sediment, although that sediment will have absorbed some water, yet the alcohol will have received much of the chloride, and thus have been rendered impure. The action produced by pouring alcohol upon the chloride of calcium is very energetic, so that great heat is extricated, as may be tried by putting just as much alcohol to some powdered and dry chloride of calcium as will render it damp.

905. *Manufacture of bleaching powder.*—The ingredients for making chlorine are introduced into a still similar to that of *Ex.* 282. The still is connected with a square leaden chamber, containing milk of lime, (lime white.) As soon as the chlorine is liberated by a fire placed beneath the still, it is absorbed by the lime solution, changing that into a hydrated chloride of lime. It may be afterwards dried or not, according to the purpose for which it is required. A short account of bleaching by its use is shown in *Ex.* 293.

906. Put a few drops of a solution of indigo into a clear solution of the chloride of lime ; the color of the indigo will be immediately destroyed. The same may be tried by most other vegetable colors. Plants also will be bleached by soaking them in this solution.

907. *Disinfecting properties.*—The chloride of lime readily parts with its chlorine to

the atmosphere, consequently it is valuable as a disinfecting liquid, as was shown in *Ex.* 289.

908. *Homberg's phosphorus.*—This is nothing more than common salt, kept at a red heat until it fuses. In this state it has phosphorescent properties, hence the name.

Union of chlorine of lime with sulphuric acid, forming a solid. See *Ex.* 17.

909. *Union of chloride of calcium with carbonic acid.*—Pass into a solution of chloride of calcium, a stream of carbonic acid gas—the solution will first become turbid, and soon afterwards a solid mass. In this experiment chlorine escapes, and the calcium uniting with the carbonic acid, becomes a carbonate of lime or chalk, giving to the fluid an appearance of chalk and water, more or less thick according to the quantity of water.

910. *Chloride of barium.* ($Ba+C=105.$) *Muriate of baryta.*—This white substance soluble in water is a valuable test for sulphuric acid. It may be procured by heating a little of the earth baryta, and immersing it in a jar of chlorine, or of hydrochloric acid gas; in the latter case, it generally becomes red hot, owing to the rapid union of the acid and the base.

911. *Chloride of strontium.* ($Str+C=80.$)—To procure this chloride, the same method may be procured as for the chloride of barium.

912. *Chloride of magnesium.* ($Mag+C=48.$)—Pass chlorine through a tube containing red hot magnesia, or mix in a retort, 1 part of magnesia with 2 of sal-ammoniac.

913. *Protochloride of manganese.* ($Man+C=64.$)—Let fall into a tall jar of chlorine some powdered metallic manganese, they will unite, the metal will burn, and a chloride of manganese be formed.

914. *Protochloride of iron.* ($Fer+C=64.$)—Pass a stream of chlorine over red hot iron filings.

915. *Second method.*—Make a solution of protoxyde of iron in hydrochloric acid, and evaporate to dryness out of contact with the air. This is best done by putting the solution in a still, and applying heat beneath. It is a brittle grey substance. When united with water it forms the

916. *Hydrated protochloride of iron,* which forms upon evaporation, small green, soluble crystals. In this state it is commonly called the protomuriate of iron.

917. *Perchloride of iron.* ($Fer+C1\frac{1}{2}=64.$)—See *Ex.* 306. It may be obtained also by exposing the protochloride of iron to the air, in a shallow vessel. Berzelius says that if a solution of the former be exposed for some days to the atmosphere in a tall jar, and a few drops of ammonia be then introduced at different depths, as it may easily be by a glass tube, the precipitate near the surface will be green, a little lower blue, still lower grey, then of a dirty white, and at the bottom quite white; provided the solution has not been so long exposed as to have become oxydated throughout.

918. *Protochloride of tin.* ($Sta+C=94.$)—Dissolve tin filings in hydrochloric acid, evaporate to dryness without the contact of the air, and heat the residue till it fuses. It is a grey semi-transparent crystalline solid, which was formerly called *butter of tin.*

919. *Perchloride of tin.* ($Sta+C=94.$)—Heat the protochloride in contact with chlorine gas, or burn tin filings in chlorine, as in *Ex.* 303. It is a transparent fuming fluid, and was formerly called Libavius's fuming liquid.

Neither of the above compounds is the liquid used so extensively by dyers and calico printers, which is the *hydrochlorate* of tin, or rather the hydrochlorate of the protoxyde of tin.

920. *Decomposed by zinc.*—To a solution of the perchloride of tin add metallic zinc; a decomposition takes place, the zinc seizes upon the chlorine, forming a chloride of that metal, and metallic tin falls to the bottom.

921. *Chloride of cobalt.* ($Cob+C=66.$)—To procure this curious substance, see *Ex.* 307; the result of which is this chloride. It may also be obtained by heating to redness the hydrochlorate of this metal, obtained by dissolving zaffre or smalt in hydrochloric acid. When dry, it is a blue substance, when dissolved in water, it yields a pink solution.

922. *Hellot's sympathetic ink.*—This is a solution of the chloride of cobalt, (or hydrochlorate of cobalt though containing undecomposed acid will do as well). If the pink solution of this chloride be diluted and written with, the characters will be invisible, but when held to the fire, the moisture is driven off, and as the chloride when perfectly dry is blue, so the letters written will be blue, they being merely a deposition of the chloride. Taken away from the fire, the blue chloride rapidly absorbs moisture, and becomes as in the first instance colorless. The chloride of cobalt, like numerous instances in chemistry, shows that the dry or anhydrous state of a body, is different in color from the hydrated state of it.

923. *Magic landscapes or Protæan pictures.*—The property of change of color of certain salts or combinations, by dryness and moisture, gives rise to these well-known and curious objects. The chief salts employed for the purpose of painting them are the

chloride of cobalt, which, as before stated, gives a fine blue; the acetate of cobalt, which heated in the same manner yields a green color, and the chloride of copper, a yellow. If then a winter landscape be painted, and a weak solution of either of the above be washed over it, using the appropriate color for the different parts, the picture will, whenever held to the fire, or exposed to the direct rays of the sun, assume the colors blue, green, and yellow—changing at once a dreary view of winter into the bright hues of summer; yet returning again to their dreary aspect when breathed upon or laid aside so that they may imbibe ever so little moisture.

924. *Chloride of nickle.* ($\mathrm{Nic}+\mathrm{C}=64.$) —Is procured in the same way as the chloride of cobalt in *Ex.* 397.

925. *Chloride of copper.* ($\mathrm{Cu}2+\mathrm{C}=100.$) —Put 2 parts of corrosive sublimate to 1 of copper filings, into a retort. The residuum left after distillation will be the dichloride of copper; or pass a stream of chlorine for a short time over copper filings contained in a tube. It is insoluble in water, but soluble in hydrochloric acid. To this solution add water, when the dichloride will be thrown down in the form of a white granular hydrate. Previous to its solution it is generally greenish brown, but when fused and slowly cooled it is yellow, translucent, and crystalline.

926. *Hydrated dichloride of copper, submuriate of copper, Brunswick green.*—Let slips of copper be wetted with hydrochloric acid, and then exposed to the air; again wetted and exposed; and so on alternately until the whole of the copper is resolved into a green powder. Very much used by house painters for common out-door work, such as palings, doors, gates, &c., and is the green usually employed for such purpose. It is a good color when first laid on, and for some time afterwards; but after some time, especially if it be the winter season, it becomes partly changed into the dioxyde of copper, and assumes a blackish-green tint. No green color is so cheap as this.

927. *Chloride of copper.* ($\mathrm{Cu}+\mathrm{C}=68.$) —Dissolve the protoxyde of copper in hydrochloric acid, and evaporate the solution to dryness by a very gentle heat, (otherwise it becomes decomposed)—gaseous chlorine is expelled, and the dichloride is formed. Its color is yellow, but when mixed with water it gives a whitish or greenish solution, according to the quantity of water used. This is one of the solutions spoken off in *Ex.* 908, as being used in painting Protæan pictures, and as giving when heated a yellow color, though invisible when damp. This hydrated chloride is commonly called the *muriate of copper*.

928. *Beautiful sympathetic ink.*—A very beautiful blue sympathetic ink may be made by the muriate of copper. First, write with the solution, the letters will be invisible. Then wash them over with liquid ammonia, when they will appear of a fine blue color.

929. *Chloride of lead.* ($\mathrm{Pl}+\mathrm{C}=140.$)—Made in the same way as the protochloride of iron. (See *Ex.* 915.) It is a horn-like substance, therefore sometimes called *plumbum corneum.* It may also be obtained by adding hydrochloric acid to the nitrate of lead. It is soluble in 30 times its weight of cold and 22 times its weight of hot water.

930. *Patent yellow, or mineral yellow; preparation of.*—This beautiful pigment is a compound of the chloride and oxyde of lead. It is made by adding a solution of common salt to litharge, which is the protoxyde of lead. A decomposition takes place, especially when assisted by heat. The hydrochloric acid of the salt unites with part of the litharge, forming a chloride, while the soda remains dissolved in the water, and may be poured off. The precipitate is washed, dried, and fused in crucibles; it is then known as patent yellow, requiring only to be pulverized, when it will be ready for the use of the painter.

931. *French method of preparation.*—The following method, by M. Chaptal, (the oldest on record,) is still employed by the French in manufacturing this pigment:—4 parts of litharge, reduced to an impalpable powder, are moistened with 1 part of common salt, dissolved in 4 of water. It is then formed into a thin paste, and suffered to remain undisturbed until it begins to whiten; it must then be stirred well with the spatula, to prevent its growing too hard.

In proportion as the consistency increases, salt is added; and if it appears that there is not sufficient of this ingredient, water must be added to retain the paste in a proper condition. In about 24 hours this compound should have become well bleached, very compact, and quite free from lumps: but it must still be stirred occasionally, to complete the decomposition; it is then to be carefully washed, to deprive it of the soda, which will be found separated from the marine salt, and the white paste must then be placed to drain on a filter. When dry, it is reduced to powder, and exposed in the receiver of a reverberatory furnace, until it assumes the yellow color required; this powder is then to be thrown into a crucible which has been brought up to a red heat, and is then returned into the furnace, where it is only allowed to remain until the composition has melted; thus fused, it is thrown on a plate of iron; and when cool, it forms a crystalline mass striated transversely.

932. *English methods.*—Acetate of lead is first decomposed by marine salt: the chlorine, as in the former instance, is separated from the soda, and forms a new combination with the lead; this chloride of lead is then carefully washed, and when dry is mixed with a certain quantity of pulverized litharge; it is then melted quickly in a crucible, and thrown upon a plate of iron; but according as the mixture is exposed for a longer or shorter time to the action of fire, the shade of color will be lighter or darker; the heat is therefore to be kept equal; the crucibles are heated to red heat at first, and withdrawn when they have become so.

933. In the following process bismuth and antimony are used, and should have the effect of rendering the color more permanent. They are ground apart, that the proportions may be exactly ascertained, which are as follow:—Bismuth, 3 parts, sulphuret of antimony, 24 parts, nitrate of potass, 64 parts. This mixture is to be dropped by degrees into a heated crucible; when dissolved, it must be thrown into a vessel of water, where it is to remain, and must be well stirred for the requisite time. It must then be repeatedly decanted until the water has lost all its smell; it is then to be filtered, and the oxide thus obtained is a fine powder, of an impure yellow tint. An eighth part of this oxide perfectly dry, is then mixed with 1 part of hydrochlorate of ammonia and 16 of very pure litharge. The fusion is then to be carried on as in the last process; great care must be taken, however, that the becoming red hot, and the duration of the process, shall be exactly the same. It is as well to be aware, that the best crucibles will not be able to sustain more than three or four operations; and also, that they do not stand the heat, if kept exposed to the fire during a longer time than is required to fuse the mixture.

934. *Protochloride of antimony, sesquichloride of antimony,* $(An + C\,1\frac{1}{2} = 119,)$ produced by *Ex.* 308, or by distilling 1 part of metallic antimony reduced to powder with 2 parts of the perchloride of mercury. It is thus procured soft like butter, therefore called the *butter of antimony* by the old authors. There is no hydrated protochloride of antimony; for as soon as water is added, a mutual decomposition ensues, and the protoxyde of antimony is deposited, while free hydrochloric acid is left in solution. The reason of the formation of the new compounds is, that both the chloride and water being decomposed, the chlorine of the one seizes the hydrogen of the other, forming the hydrochloric acid, while the oxygen of the water uniting with the antimony forms the protoxyde of that metal.

935. *Perchloride of antimony.* $(An = C\,2\frac{1}{2} + 155.)$—Pass dry chlorine over heated antimony until it will absorb no more; it will first become the protochloride, and afterwards the perchloride. Dissolved in water, a partial decomposition only takes place; muriatic acid is formed as in the last experiment, but the precipitate is an hydrated peroxyde of antimony, and not a protoxyde, as is formed by the protochloride.

936. *Chloride of bismuth, butter of bismuth.* $(Bis + C = 108.)$—Made by burning bismuth in chlorine, as in *Ex.* 304, or by evaporating to dryness with a gentle heat the solution of bismuth in hydrochloric acid.

937. *Chloride of arsenic, butter of arsenic,* $(Ar + C\,1\frac{1}{2} = 82,)$ obtained in the same manner as the other chlorides. See *Ex.* 305.

938. *Chloride of chromium, sesquichloride of chromium.* $(Chr + C1\frac{1}{2} = 82.)$—Heat to redness a mixture of dry protoxyde of chromium and charcoal, and pass through it a stream of chlorine gas. An easier method of production is to dissolve the protoxyde in hydrochloric acid. It may also be made by adding hydrochloric acid to the chromate of lead, (chrome yellow;) in both these cases the result, which is the hydrated chloride, requires to be brought to nearly a red heat, to be obtained anhydrous.

939. *Perchloride of chromium, terchloride of chromium.* $(Chr + C\,3 = 136.)$—Professor Brande, writing of the terchloride of chromium, says, "This compound may be obtained by distilling a mixture of chromate of lead, chloride of sodium, and sulphuric acid, and conducting the evolved vapor, which is a mixture of chlorine, hydrochloric acid, and terchloride of chromium through a tube cooled to 0°; by which the latter is condensed into a dark-colored liquid, heavier than water, very volatile, and exhaling fumes in the air of the color of nitrous acid. It acts violently on water, and produces a hydrochloric solution of chromic acid; it absorbs chlorine and dissolves iodine. A small fragment of phosphorus, brought into contact with this liquid, inflames and explodes, it is also rapidly decomposed by sulphur and mercury."

940. *Chloride of mercury, calomel, mild muriate of mercury, protochloride of mercury of Brande.*—"This compound so valuable in medicine, is procured by abstracting chlorine from the bichloride, by a decomposition of the nitrate of mercury or other similar methods. The following are useful recipes:—1st. method. Mix 4 parts of the bichloride of mercury (corrosive sublimate) with 3 of metallic mercury, rub them together in a mortar with a few drops of water, until the whole assumes the character of a grey powder. This grey powder is then put in a subliming apparatus similar to that

of *Ex.* 164; upon heat being applied, the calomel sublimes, attended with a little of the bichloride—this may be separated by washing the sublimed mass with hot distilled water, this will dissolve the bichloride, and leave the chloride pure.

941. *Second method.*—Boil 2 pounds of mercury, with 30 ounces of sulphuric acid in a glass vessel, until the sulphate of mercury is dry. Then when cold, rub it in a mortar with 2 pounds of mercury. When mixed, add 1½ pounds of common salt, and rub the whole together again. This mixture when sublimed yields calomel as before. The rationale of the above experiment is as follows:—The metal and sulphuric acid first boiled together form a persulphate, this is rubbed with more of the metal to change it to a protosulphate. By the trituration of the protosulphate with chloride of sodium, it becomes converted into the protochloride, the chlorine combining with the mercury of the oxyde of mercury in the protosulphate, whilst its sodium uniting with the acid becomes sulphate of soda.

942. *Third method.*—Form a protonitrate of mercury, by dissolving as much mercury as possible in nitric acid; then dissolve in boiling water a quantity of common salt, add this to the protonitrate, when the chloride is immediately precipitated. The quantity of salt used should be about equal to that of the metallic mercury in the nitrate.

Sublimation of. See *Ex.* 171.

943. *Bichloride of mercury, corrosive sublimate, perchloride of mercury, oxymuriate of mercury, &c.*—Burn mercury in chlorine as in *Ex.* 300, the result is this substance. Also it may be procured by dissolving the peroxyde of mercury in hydrochloric acid, drying the solution, redissolving and recrystallizing the residuum.

944. The bichloride may be made in the same manner as the chloride in *Ex.* 940, omitting that part of the process wherein the sulphate is triturated with metallic mercury.

Note.—This substance is the most virulent poison, and its fumes no less than the solution, highly dangerous to imbibe. We therefore advise the young experimentalist not to operate at all with it, as for experimental purposes it may well be dispensed with.

Preserving objects of natural history.—A solution of corrosive sublimate, so weak that when a black feather is dipped into it and afterwards dried, it shall exhibit no whiteness—is used by botanists and entomologists to wash over their collections of plants or dried animals, to preserve them from the attacks of minute insects or the growth of mould and other small fungi.

945. *Chloride of silver, horn silver, luna cornea.* (Arg + C = 144.)—This important compound is obtained, not by direct combination of silver and chlorine like most of the chlorides previously described, but by decomposing the nitrate of that metal, by adding to it chlorine either in its free state, passing chlorine gas through a solution of the nitrate; or by adding to it hydrochloric acid, which while it combines with the silver to form the chloride sets free at the same time both water and nitric acid; or 3rd, by adding common salt to the nitrate solution, when a double decomposition takes place, the chlorine of the salt attacks the silver and leaves the sodium to unite with the nitric acid. It may be crystallized and also fused, in which latter case it constitutes *horn silver.*

946. Any other salt of silver except the hyposulphite may be in like manner decomposed by chlorine and its salts; hence the chlorine of silver may be in like manner procured from the acetate, sulphate, carbonate, &c.

947. *Effect of light upon chloride of silver.*—The chloride of silver which is a white powder, insoluble in water; when exposed to light changes first to a lavender or grey color, then brownish purple, and finally black. A knowledge of this fact gave rise to the art of *photogenic drawing,* and that by other experiments to the *calotype* pictures. As these arts are but modifications of each other, it will be advisable to treat of both together, though the latter involves principles, and requires materials different from that class of bodies which we are now considering.

PHOTOGRAPHY AND THE CALOTYPE.

This art may be described briefly as the production of a monochromatic picture, or picture of one color, by means of the action of light upon certain salts, particularly those of silver and gold. In several old books the following experiment is given:—

948. "Dissolve chalk in aquafortis to the consistence of milk, and add to it a strong solution of silver; keep this liquor in a glass decanter well stopped, then cutting out from a paper the letters you would have appear, paste it on the decanter, and lay it in the sun's rays in such a manner that the rays may pass through the spaces cut out of the paper, and fall on the surface of the liquor; then will that part of the glass through which the rays pass be turned black, while that under the paper will remain white; but particular care must be taken that the bottle be not moved during the operation."

This experiment though so vaguely expressed and so doubtful of success, that it was perhaps never tried, is nevertheless the first record of the art we are about to describe, joined to the well-known fact, that upon using the nitrate of silver as a caustic to the skin, or as a marking ink for linen, a perfectly black color is produced by exposure to light. And although it is preferable to employ the chloride of silver, yet as the above experiments show, the nitrate will to a certain extent answer the same purpose. And the effect is in proportion to the intensity of the light—a direct sunshine upon making the prepared paper afterwards described, occasioning a much more rapid change than a diffused light. The subject was afterwards pursued by Sir H. Davy and Mr. Wedgewood in 1802, whose experiments are recorded in an early volume of the "Transactions of the Royal Institution." These experiments were not afterwards pursued by others because of the impossibility of at that time *fixing* the pictures, or in other words of continuing the blackness to one part, and rendering the other part of the paper unchangeable. The subject was revived early in 1841, on account of a statement that M. Daguerre, of Paris, had discovered a method to produce minute and elaborate drawings of the most complicated subjects, without aid from the pencil, his only artist being the sun. Soon after the above account was published, Mr. Fox Talbot communicated in the "Philosophical Magazine," that he also for about four years had been acquainted with a process analogous to that of M. Daguerre, and which he called photography.

The processes of this art are three.—1st. The preparation of a paper sensitive to light. —2nd. The method of impressing upon it the object to be delineated, and—3rd. The fixing that picture afterwards.

949. ***Preparation of the paper*;—*Mr. Talbot's first method*.**—"Take superfine writing paper, and dip it into a weak solution of common salt, and wipe it dry, by which the salt is uniformly dispersed throughout its surface. Then spread a solution of nitrate of silver on one surface only, and dry it at the fire. The solution should not be saturated, but six or eight times diluted with water: when dry the paper is fit for use." Mr. Talbot says, "This paper, if properly made, is very useful for all ordinary photogenic purposes. For example, nothing can be more perfect than the images it gives of leaves and flowers, especially with a summer's sun, the light passing through the leaves delineates every ramification of their nerves.

"To render this paper more sensitive, it must be again washed with salt and water, and afterwards with the same solution of nitrate of silver, drying it between times.

"In conducting this operation, it will be found that the results are sometimes more, and sometimes less satisfactory, in consequence of small and accidental variations in the proportions employed. It happens sometimes that the chloride of silver is disposed to blacken of itself, without any exposure to light. This shows that the attempt to give it sensibility has been carried too far. The object is to *approach* to this condition as near as possible without *reaching* it, so that the substance may be in a state ready to yield to the slightest extraneous force, such as the feeble impart of the violet rays when much attenuated."

In this process the salt or chloride of sodium is acted upon by the nitrate of silver, and both salts become decomposed. The silver held in solution by the nitric acid, having a greater affinity for the hydrochloric acid of the salt, unites with it, and forms chloride of silver, while the nitric acid and soda are set free. These uniting together, form the nitrate of soda, which is very soluble in cold and hot water.

950. ***Mr. Cooper's receipt*.**—"Soak the paper (he prefers *laid* or water-marked paper) in a boiling-hot solution of chlorate of potass for a few minutes; the strength of the solution is of little consequence: then take it out, dry it, and wet it with a brush on one side with nitrate of silver, 60 grains to an ounce of water, or if not required to be very sensitive, 30 grains to the ounce will do." This paper has a very great advantage over any other, for it can be fixed by washing with *common water*. It is, however, very apt to become discolored, even in the making, or shortly afterwards, and is besides not so sensitive, nor becomes so dark as that made with common salt.

951. ***M. Daguerre's method*.**—"Immerse a sheet of thin paper in hydrochloric (or as it is commonly called muriatic) ether, which has been kept sufficiently long to have become acid; the paper is then carefully and completely dried, as this is stated to be essential to its proper preparation. The paper is then dipped into a solution of nitrate of silver (the degree of concentration of which is not mentioned), and dried, without artificial heat, in a room from which every ray of light is carefully excluded. By this process it acquires a very remarkable facility in being blackened on a very slight exposure to light, even when the latter is by no means intense. This paper rapidly loses its extreme sensitiveness to light, and, finally, becomes not more readily acted upon by the solar beams, than paper dipped in nitrate of silver only."

952. ***Mr. Golding Bird's method*.**—This is a modification of Mr. Talbot's process. It consists in using 200 grains (nearly ½ an ounce) of salt to a pint of water—soaking the paper in it—taking off superfluous moisture between the folds of bibulous paper, or by a cloth; while still damp, to be washed

on one side with a solution of 20 grains of fused nitrate of silver (lunar caustic) in an ounce of water, and hung up in a dark room to dry. This, Mr. Bird observes, produces a rich mulberry tint.

953. *To make the drawings.*—Place upon a flat surface a piece of the photogenic paper, with the prepared side upwards, upon this the object to be delineated, and cover it with a piece of flat glass, (plate glass is the best); expose this to diffused daylight, or still better to the direct rays of the sun, when that part of the paper not covered with the object will immediately become tinged with a violet color; and if the paper be good, in a few minutes pass to a deep brown, or bronze black color. It must then be removed, as no good will be obtained by keeping it longer exposed; on the contrary, the delicate parts yet uncolored will become in some degree affected. The photogenic paper will now show a more or less white and distinct representation of the object chosen.

It must be evident, that the closer the contact of the paper and object the finer will be the outline. To accomplish this it is common to take a book cover, or a piece of wood, and lay upon it first three or four folds of flannel, or what is better, a pad of cotton wadding, the paper, object, and glass upon this, and to tie them together as tightly as possible, or else to place moderately heavy weights upon the corners of the glass. This contrivance, or something similar, is absolutely necessary. Suppose, for example, we have a daisy flower as an object, the centre of the flower is so thick that it will bear up the glass from touching the rest of the flower consequently the stalk, and still more so the delicate white petals or flower leaves will not touch the prepared paper beneath, and the effect of sharpness of outline destroyed. Another suggestion is also called for. When the object, &c., is offered to the sun, it should be in a position perpendicular to his beams, or a distortion of parts is liable to occur if of irregular body.

The objects which appear to be delineated with best effects are lace, especially black lace—printed and checked muslins—feathers—dried plants, particularly the ferns, the sea-weeds, and the light grasses—impressions of copper-plate and wood engravings, if they have considerable contrast of light and shade, (these should be put face downwards,) figures painted on glass, such as on magic lanthorn sliders, stained windows, &c. The following is the representation of objects thus delineated.

954. *To fix the drawings.*—To do this with certainty is most difficult. Mr. Talbot says, "That to dip the drawings into a saturated solution of salt and water is sufficient to fix them, that is, to prevent change when the finished drawings should afterwards be subjected to light." This receipt may succeed occasionally, but it does not always, though certainly it retards, at all times, further discoloration.

Iodide of potassium, or as it is more frequently called, hydriodate of potass, dissolved in water, and very much diluted, is a more useful preparation to wash the drawings with—it must be used very weak, or it will not only dissolve the unchanged muriate as is intended, but the blackened oxide also, and the drawing be thereby spoiled.

The most certain material to be used is one of the hyposulphites, as proposed by Sir W. Herschell, who, very many years since, showed the peculiar effects of these salts in decomposing the nitrate, muriate and carbonate of silver. Washing the photogenic drawing with a solution of hyposulphite of soda, no matter as to the strength of the solution, the muriate which lies upon the lighter parts of it will become altered so much in their nature as to become unalterable to light, while the rest remains dark as before.

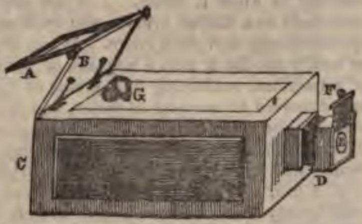
Before using either of these preparations for fixing the drawings, they should be soaked for a minute or two in hot water, which of itself removes a large portion of the muriate of silver that is to be got rid of.

Suppose the drawings when taken are to be seen only by candle-light, or are required only to put in a portfolio, that they may be sent to a distant place, no preserving preparation will be necessary: thus travellers need not trouble themselves to wash their pictures, till at a future time when they may have greater leisure.

It will be evident, from the nature of the above process, and also from the preceding cut, that the color of an object is reversed. That which is in the original black, or rather that which is opaque, will most intercept the light; and consequently those parts of the photogenic paper beneath will be least influenced by the light, while any part of the object which is transparent, by admitting the light through it, will suffer the effect to be greater or less, in exact proportion to its more or less transparency. In the cut on the preceding page, the plant wholly intercepting the light will show a white impression. The butterfly, being more or less transparent, leaves a proportionate gradation of light and shade; the most opaque part of the animal of course showing the whitest color. It may be said that therefore the representation is not natural. This is admitted, and in order that we should obtain a just delineation, we must place the first acquired photograph, and which should have been obtained on the thinnest paper, upon a second piece of photogenic paper. The light will now penetrate the whiter parts, and the second photograph be the reverse of the former, or a true picture of the original, as may be seen by comparing the following with the foregoing cut:—

Application.—Mr. Talbot has recorded so many applications of his process, besides those before alluded to, that little can be added to his list. The first advantage which he alludes to is taking of portraits or silhouettes, by means of the shadow thrown upon the paper by the living face. Second, the copying of paintings on glass by the light thrown through them on the prepared paper. Thirdly, another imitation is that of etchings; this was suggested by Mr. Havell, and since also claimed by Mr. Talbot. This is done by painting a piece of glass with a thick coat of white oil paint; when dry, with the point of a needle, lines or scratches are to be made through the white-lead ground, so as to lay the glass bare; this being done, place the glass upon a piece of the paper, and of course every line will be represented beneath of a black color, and thus an imitation etching will be produced. Fourthly, microscopic objects. Fifthly, the delineation of architecture, sculpture, landscapes, and external nature.

Relative to copying this class of objects, and also those seen by the microscope, reflected instead of direct light must be employed, and of course some instrument containing a reflector. The chief instruments of this character are the camera obscura and the solar microscope. The former is applicable to take views of scenery, equally with small objects, and to diminish the view, according to the desire of the operator, by removing the camera more or less distant from the object represented, or by using another camera with a lens of longer focus. For this purpose any common camera will succeed, but one particularly adapted, and very simple in construction, may be made as follows:—



It is a wooden box, about a foot long, 6 inches wide, and 4½ deep. The end C is shown as if open, but when in use it is covered by the wooden flap B, fastened to it by hinges. This has a light tin frame attached to its upper end, which shuts down upon it, and when B is folded down, so as to cover the end C, the frame A is inclosed with the box. On the top of the box at G is a small hole, covered with a shutter. At the end D is a sliding tube, with a double convex lens E in the end of it, and a slide F which passes over it, and shuts off the light. To use the instrument, put a piece of common white paper between A and B; then shut down B. Place the camera before the landscape, and move the tube D, until by looking through G a clear view of the prospect is seen on the paper. Now, without moving the box, or disarranging the focus, shut G and F—open

C, and place as quickly as possible a piece of photogenic paper, instead of, or over the common paper. When C is again closed open F, and as the light will now fall upon the inner part of C, it will depict the objects there on the paper. By looking through G the progress of the operation may be ascertained. When done, remove the box into a dark room, and take it out of the frame.

The Calotype is closely allied in effect to the art we have now described. The Daguerreotype is also dependent upon the chemical effect of light. These processes are however not connected with the properties of the chlorides, but rather of the iodides and bromides; yet making an allowance for forestalling the consideration of those chemicals, it would be advisable to explain the arts connected with photography, and first the *Calotype*. The following abstract from Mr. Talbot's paper, read lately before the Royal Society on this subject will be sufficiently explicit, especially as the camera to be used, and the manipulation requisite, are precisely the same as in photography. Mr. Talbot says :—

955. *Preparation of the paper*—"Take a sheet of the best writing paper, having a smooth surface, and a close and even texture. Dissolve 100 grains of crystallized nitrate of silver in 6 ounces of distilled water.—Wash the paper with this solution, with a soft brush, on one side, and put a mark on that side whereby to know it again. Dry the paper cautiously at a distant fire, or else let it dry spontaneously in a dark room. When dry, or nearly so, dip it into a solution of iodide of potassium, containing 500 grains of that salt dissolved in one pint of water, and let it stay two or three minutes in this solution. Then dip it into a vessel of water, dry it lightly with blotting-paper, and finish drying it at a fire, which will not injure it even if held pretty near; or else it may be left to dry spontaneously. All this is best done in the evening by candlelight. The paper, so far prepared, the author calls *iodized paper*, because it has a uniform pale yellow coating of iodide of silver. It is scarcely sensitive to light, but, nevertheless, it ought to be kept in a portfolio, or a drawer, until wanted for use. It may be kept for any length of time without spoiling or undergoing any change, if protected from the light. This is the first part of the preparation of Calotype paper, and may be performed at any time. The remaining part is best deferred until shortly before the paper is wanted for use. When that time is arrived, take a sheet of the *iodized paper*, and wash it with a liquid prepared in the following manner :—Dissolve 100 grains of crystallized nitrate of silver in 2 ounces of distilled water; add to this solution $\frac{1}{6}$ of its volume of strong acetic acid. Let this mixture be called A. Make a saturated solution of crystallized gallic acid in cold distilled water. The quantity dissolved is very small. Call this solution B. When a sheet of paper is wanted for use, mix together the liquids A and B in equal volumes, but only mix a small quantity of them at a time, because the mixture does not keep long without spoiling. I shall call this mixture the *gallo-nitrate of silver*. Then take a sheet of *iodized paper* and wash it over with this *gallo-nitrate of silver*, with a soft brush, taking care to wash it on the side which has been previously marked. This operation should be performed by candlelight. Let the paper rest half a minute, and then dip it into water. Then dry it lightly with blotting paper, and finally dry it cautiously at a fire, holding it at a considerable distance therefrom. If it is used immediately, the last drying may be dispensed with, and the paper may be used moist." Instead of employing a solution of crystallized gallic acid for the liquid B, the *tincture of galls* diluted with water may be used, but he does not think the results are altogether so satisfactory.

Use of the paper.—The *Calotype paper* is sensitive to light in an extraordinary degree, which transcends a hundred times or more that of any kind of photographic paper hitherto described. This may be made manifest by the following experiment :—

956. Take a piece of this paper, and having covered half of it, expose the other half to daylight for the space of *one second* in dark cloudy weather in winter.—This brief moment suffices to produce a strong impression upon the paper. But the impression is latent and invisible, and its existence would not be suspected by any one who was not forwarned of it by previous experiments. The method of causing the impression to become visible is extremely simple. It consists in washing the paper once more with the *gallo-nitrate of silver*, prepared in the way before described, and then warming it gently before the fire. In a few seconds the part of the paper upon which the light has acted begins to darken, and finally grows entirely black, while the other part of the paper retains its whiteness. Even a weaker impression than this may be *brought out* by repeating the wash of gallo-nitrate of silver, and again warming the paper. On the other hand, a stronger impression does not require the warming of the paper, for a wash of the gallo-nitrate suffices to make it visible, without heat, in the course of a minute or two. This paper, being possessed of so high a degree of sensitiveness, is therefore well suited to receive images in the camera obscura. The images thus received upon the Calotype paper are for the most part invisi-

ble impressions. They may be made visible by the process already related, namely, by washing them with gallo-nitrate of silver, and then warming the paper. When the paper is quite blank, as is generally the case, it is a highly curious and beautiful phenomenon to see the spontaneous commencement of the picture, first tracing out the stronger outlines, and then gradually filling up all the numerous and complicated details. The artist should watch the picture as it developes itself, and when in his judgment, it has attained the greatest degree of strength and clearness, he should stop further progress by washing it with the fixing liquid.

957. *The fixing process.*—To fix the picture, it should be first washed with water, then lightly dried with blotting paper, and then washed with a solution of *bromide of potassium*, containing 100 grains of that salt dissolved in 8 or 10 ounces of water. After a minute or two it should be again dipped in water and then finally dried. The picture is in this manner very strongly fixed, and with this great advantage, that it remains transparent, and that, therefore, there is no difficulty in obtaining a copy from it. The Calotype picture is a *negative* one, in which the lights of nature are represented by shades; but the copies are *positive*, having the lights conformable to nature.

THE DAGUERREOTYPE.

Description of the process—The reproduction of the images received at the focus of the camera obscura is effected on plates or surfaces of silver, which may be plated on copper; the copper serving to support the surface or sheet of silver, and the combination of these two metals contributing towards the perfection of the effect. The silver employed should be without alloy, or as pure as possible. The thickness of the two metals united need not to exceed that of a stout card. The process is divided into five operations; the first consists in polishing and cleaning the silver surface of the plate, in order to properly prepare or qualify it for receiving the sensitive layer or coating upon which the action of the light traces the design. The second operation is the applying that sensitive layer or coating to the silver surface. The third in submitting, in the camera obscura, the prepared surface or plate to the action of the light, so that it may receive the images. The fourth in bringing out or making appear the image, picture or representation, which is not visible when the plate is first taken out of the camera obscura. The fifth and last operation is that of removing the sensitive layer or coating, which would continue to be affected and undergo different changes from the action of light—this would necessarily tend to destroy the design or tracing so obtained in the camera obscura.

The plates must first be well cleaned and polished. To effect this, begin by sprinkling the silver surface with very fine dry pounce; then with cotton impregnated with a little olive oil, rub it gently on, lightly moving the hand in circles from the centre. The pounce must be sprinkled several times, and the cotton changed several times during the operation of rubbing. Next a small knot or tuft is made with carded cotton, which is to be moistened with a little nitric acid, diluted with 16 times as much water. It will be seen that the acid is evenly spread upon the surface of the plate by its appearing covered with a uniform tint, or what may be called a thin veil, or change of surface. The plate is finally to be sprinkled with pounce or pumice powder, and cleaned by slightly rubbing it with a piece of carded cotton; instead of ordinary pounce calcined Venetian tripoli may be used. The plate thus prepared is then to be submitted to a considerable degree of heat; to do this it is placed on a wire frame, the silver surface being uppermost. Under the plate is to be placed a lighted lamp, which is to be moved about so that the flame shall act equally upon all parts. When the plate has been submitted for about five minutes to this operation, (or until the heat has acted equally upon all parts of the plate) it will be perceived that the surface of the silver has obtained a whitish tint, or coating, and then the action of heat must cease.

The plate is next to be cooled rapidly, by placing it on a cold body or substance, such as a marble slab, or stone or metal surface; when cooled, it must be polished again. This may be quickly done, since it is only necessary to remove the white tint which has been formed on the silver surface. To effect this, the plate is to be sprinkled with pumice powder, and rubbed in a dry state with a portion of cotton; this should be done on the surface of the plate several times, taking care to change the cotton often. When the silver is well polished, it is to be rubbed again, with acid dissolved in water, and sprinkled with a little dry pounce powder, and rubbed slightly with a knot of cotton. The acid is then to be laid upon the plate, say, three different times, care being taken to sprinkle each time the plate with powder, and to rub it dry and very lightly with clean cotton; care should be taken not to breathe upon the plate, or touch it with the parts of the cotton touched by the fingers as the perspiration would produce spots or stains, and dampness of the breath or of the saliva would produce the same defects in the drawings. Finally, the plate must be cleaned with cotton, from all pounce dust which may be on the surface or its edges.

Coating the surface.—For this operation are required the following implements: a box, as represented in the annexed figure 1, and a phial of iodine.

Some powdered iodine is to be put into a dish and placed in the bottom of the box. A thin board with the plate fastened to it is then placed with the surface undermost, upon small brackets or supports, at the four angles of the box; its cover is then closed. In this position the plate must be left, until the surface of the silver be covered with a fine gold tinge, which is caused by the evaporation of the iodine, condensing upon the surface of the silver. If the plate were allowed to remain too long, this golden yellow color would turn to a purple or violet color, which must be avoided, because in this state the coating is not so sensitive to the effect of light. On the contrary, if this coating is too pale or not sufficiently yellow, the image taken from nature would be very deficiently or faintly reproduced, therefore a coating of a golden yellow is particularly desired, because it is the most favorable to the production of the effect. This operation should be left entirely to the spontaneous evaporation of the iodine.

When the surface of the plate has attained the proper color, the board with the plate must be introduced into a frame which is adapted to the camera obscura. In this transference, care must be taken to prevent the light striking on the surface of the plate.

Taking the picture.—The apparatus necessary for this operation is the camera obscura, figured on page 121, adapted and fitted to receive the prepared plates and their boards. This third operation is that in which, by means of light acting through the lens of the camera obscura, nature reflects or impresses an image of herself of all objects enlightened by the sun, on the surface of the photographic or prepared plates. The objects (of which the image is to be retained upon the surface of the plate) should be as much as possible lighted by the sun, because then the operation is more expeditious. This operation is of a very delicate nature, and should be carefully attended to, because nothing is visible, and it is quite impossible to state the time necessary for the reproduction of the image, as it depends entirely on the intensity of light received by or from the objects, the image of which is intended to be reproduced; the time may vary from three to thirty minutes. It is, however, very important not to allow more time to pass than what is necessary for the reproduction, because the clear parts would no longer be or remain white or clear, they would be darkened by the prolonged action of the light allowed to strike upon the iodine on the surface. If, on the contrary, the time allowed is not sufficient, then the proof or image would be vague and without proper details.

The mercurial process.—The operator must hasten to submit the surface of the plate to the fourth operation, as soon as it is withdrawn from the camera obscura. Not more than one hour ought to be allowed to expire between the third and fourth operations, and it is much more certain to obtain good proofs or tracings of nature, when the fourth operation takes place immediately after the third. For this operation are required the following implements: first, a phial containing a quantity of mercury or quicksilver; secondly, the apparatus, a cut of which is annexed. The mercury is poured into the cup, situated in the bottom of the apparatus, and in a sufficient quantity to cover the ball or globe of a thermometer, inserted in the side of the box; from this time no daylight must be admitted, and the room must be darkened, and the light of a candle or taper only be used, to enable the operator to inspect the progress of the operation. The board on which is fixed the plate must be withdrawn from the camera, then introduced in the grooves or ledges of the blackened board in the box. This board is then replaced in the box or apparatus, which maintains it at an inclination of 45°, the prepared metal surface being placed undermost, so that it may be seen through a glass at the side. The cover of the box must

be put down gently, to prevent any particles of mercury flying about in consequence of the compression of the air. When the whole is thus prepared, the spirit-lamp is lighted, and placed under the cup containing the mercury, and allowed to remain until the thermometer (the ball of which is immersed in the quicksilver bath, the tube extending outside the box) indicates a temperature of 140°; the lamp must then be removed; if the thermometer has rapidly risen it continues to rise, even when the lamp is removed, but it should not be allowed to rise above 75° Centigrade. The impression of the image of nature now actually exists on the plate, but not visibly; it is only after several minutes of time has elapsed, that faint tracings of the objects begin to appear, as may be readily ascertained by inspecting the operation, or looking through the glass assisted by the light of a candle or taper, which must not be allowed to strike too long on the plate, because it would leave marks on the same. The plate should be left in the box, until the thermometer has fallen 45°, then the plate is to be taken out, and this operation is finished.

Fixing the tracing, or picture.—The object of this operation is to remove from the surface of the plate, the coating of iodine, which otherwise on its being exposed too long to the action of light would continue to be decomposed, and would thereby destroy the picture or tracing. The plate is first to be immersed for a moment in pure water, and then without allowing it to dry, it is to be plunged immediately in a saturated solution of common salt, or still better of the hypo-sulphite of soda. To facilitate the action of the salt water, or of the hypo-sulphite which absorbs the iodine, the plate should be moved about in the liquid. When the yellow color or tint of the iodine is entirely removed from the surface of the plate, it is to be removed and carefully taken by the edges, so as not to touch or injure the drawing, and then dipped immediately in the pure water. The plate, on being withdrawn from the water, is to be placed immediately on an inclined plane, and without allowing it time there to dry. The operator is then to pour upon the surface bearing the drawing, hot distilled water beginning at the top of the plate, and pouring the water over it in such manner that it shall flow over the surface, and carry away with it all the solution of sea-salt or of hypo-sulphite, which has been already considerably weakened by the immersion of the plate in the first trough. If the hypo-sulphite has been used, the distilled water to be poured over the surface, need not be so hot as for the common salt solution. When this washing is completed, the picture, drawing or tracing is finished, the only thing now to be done is to preserve the surface from being touched, also from dust and from vapors which tarnish silver. The mercury which traces the images, or in other words, by the action of which the images are rendered visible, is partly decomposed, it adheres to the silver, it resists the washing by the water poured upon it, by its adhesion, but it will not bear any rubbing or touching. To preserve these drawings, they must be covered with glass, securely placed a little above the surface, both the edges of the glass and plate secured by pasted paper, or other means, and they are then unalterable even by the light of the sun.

958. *Perchloride and protochloride of gold.*—When the solution of gold in nitro-muriatic acid, (see *Gold*,) is evaporated, it deposits crystals of an orange color; these are the perchloride of gold, when kept, they turn first into the protochloride, and then into metallic gold. It may also be procured by burning gold in chlorine as in *Ex*. 302.

959. Moisten a piece of paper with the solution of the perchloride of gold, and expose it to the sun's light, when it will turn of a clear dark purple color.

960. *Purple of Cassius.*—Dip a piece of tinfoil in a solution of the perchloride of gold—a purple powder is presently thrown down upon it. This powder is used in enamel painting, and for tinging glass of a fine red color, it is a compound of peroxyde of tin and oxyde of gold.

Perchloride and protochloride of platinum obtained in the same way, and possessed of similar properties to the chlorides of gold.

THE IODIDES AND BROMIDES.

The iodides and bromides, or combinations of iodine and bromine with the other elements, are not of such general interest as the chlorides, and still less so than the oxides. They have many properties in common with the chlorides, and substituting the vapor of iodine or bromine for chlorine, they may be procured in the same manner, namely, by burning the element which is to be combined in an atmosphere of iodine or bromine. The combinations of these elements described in previous pages are the

Oxyde of iodine in *Ex*. 646.

Iodous acid. See *Ex*. 779.

Iodic acid. See *Ex*. 780 and 781.

Periodic acid. See *Ex*. 782.

Bromic acid. See *Ex*. 783.

Hydriodic acid. See *Ex*. 869.

Hydrobromic acid. See *Ex*. 877.

961. *Iodide of nitrogen, teriodide of nitrogen.* ($N + I\,3 = 389$.)—Pour a solution of

ammonia upon a small quantity of pulverized iodine. The iodine decomposes part of the ammonia, and combining with its hydrogen, forms hydriodic acid, and this, uniting with the ammonia, forms hydriodate of ammonia; the nascent nitrogen unites with another portion of the iodine, and forms an insoluble black powder, which may be collected by filtering the liquid, and suffering the powder to dry spontaneously on the filter. This compound is highly dangerous, and explodes by the slightest heat and friction. Touching it with a finger is sufficient, even exploding a grain or two will be terrific, and most probably occasion the explosion of the whole quantity if it be left within a moderate distance. It had better not be operated with or manufactured.

962. *Iodide of sulphur.* $(S + I = 141)$ Heat these substances together, their union will form the iodide of sulphur, which is a black crystallizable substance.

Iodide of phosphorus. See *Ex.* 331.

963. *Iodide of potassium. Ex.* 366, 367.—Add hydriodic acid to potass until saturated. This is generally called the hydriodate of potass. It may be likewise made as follows:—

964. Dissolve iodine in solution of potass, till it begins to assume a brown color; on evaporating to dryness, and fusing the residuary salts, a pure iodide of potassium remains.

965. Add carbonate of potass to iodide of zinc dissolved in water, a decomposition takes place, and iodide of potassium and carbonate of zinc are the result. The latter subsides as a powder, the former is held in solution.

966. *Iodurетted iodide of potassium.*—This is made by dissolving iodine in a solution of potassium. It is of a deep brown color.

Iodide of sodium, $(So + I = 149.)$—Made in the same way as the iodide of potassium, in *Ex.* 914.

967. *Iodide of calcium.* $(Cal + 1 = 145.)$—Dissolve chalk in hydriodic acid—the salt obtained is the hydriodate of lime, by submitting the crystals to heat they become the iodide of calcium.

968. *Iodides of barium and of strontium,* are obtained as that of calcium.

969. *Iodide of magnesium.*—Boil iodine in magnesia and water, iodide of magnesium and iodate of magnesia are formed. By concentrating the solution, both salts are partly decomposed, and a brown flocculent iodide of magnesium falls, which, when heated, loses part of its iodine and becomes a subiodide.

970. *Protiodate of iron.*—Soak together in water, iron filings and iodine—a green solution is obtained of the protiodate of the metal.

971. *Iodide of zinc.*—Add iodine to melted zinc; they will combine and form an iodide of zinc. When water is added, it becomes the hydriodate. It may be made also by merely boiling together iodine, pulverized zinc and water.

972. *Iodide of tin.*—Prepared in the same manner as iodide of zinc.

973. *Iodide of nickel.*—Add a solution of iodide of potassium to a salt of nickel, particularly to the sulphate or the nitrate.

974. *Iodide of copper.*—Add hydriodic acid to a solution of sulphate of copper. The iodide will fall as a brown insoluble powder.

975 *Iodide of lead.*—Add iodine to melted lead. It is a bright yellow powder, which has been suggested as a pigment, but has not hitherto been so much used as orpiment or chrome yellow, though thought to be more constant. For the purpose of procuring the iodide of lead as a pigment, it is preferable to decompose the acetate, or still better the nitrate of lead, by adding to its solution the chloride of potassium.

976. *Iodide of antimony.*—Pound in a mortar metallic antimony and iodine, they will unite and form a brown compound.

977. *Iodide of bismuth.*—Add iodine to the melted metal, or else add the iodide of potassium to the nitrate of bismuth. This iodide is of a deep orange color.

978. *Iodide of arsenic.*—Add iodine to the melted metal. This is of a deep red color.

979. *Protiodide of mercury.*—$(Hy + I = 325.)$—Add the iodide of potassium to a solution of the protonitrate of mercury. It is a dirty yellow powder.

980. *Periodide of mercury.* $(Hy + I\ 2 = 450.)$ *Geranium color.* This is the finest crimson color that can be formed or even imagined; unfortunately it is not permanent, changing after a few months into a yellow, and afterwards becoming quite colorless. It has hitherto been chiefly used as a water color, under the name of *geranium red.* It may be made as follows:—Dissolve the perchloride of mercury, (corrosive sublimate,) in distilled water; dissolve also the iodide of zinc in another portion of distilled water, then add the two liquids together, and immediately a large quantity of precipitate is formed. This deposit is washed first with distilled water, and afterwards with filtered river water; the precipitate is then dried. Fusing the mass afterwards makes the color darker.

981. *Iodide of silver.*—Add iodide of potassium to the solution of nitrate of silver. It is of a greenish yellow color, but when fused is red.

982. *Iodide of gold.*—Add hydriodate of potass to chloride of gold—a precipitate of the iodide of gold will be thrown down,—it is a yellowish brown powder.

983. *Iodide of platinum* is formed by heating iodide of potassium in solution, with the chloride of platinum. The chloride of potassium is held in solution, and the iodide of platinum is deposited of a dark color.

984. *Bromide of sulphur.*—Boil bromine and sulphur together in water, a red liquid of bromide of sulphur remains.

985. *Sesqui-bromide, and perbromide of phosphorus.* ($Ph + B\,1\frac{1}{2}$ and $Ph + B\,2\frac{1}{2}$.)—Mix bromine and phosphorus together in a flask containing carbonic acid gas,—the action of the bromine upon the phosphorus will be very intense, and light and heat be extricated. In this experiment a yellow crystalline perbromide of phosphorus rises to the top of the flask, while a volatile and very pungent liquid falls to the bottom. This is the sesquibromide.

986. *Bromide of potassium.*—Drop bromine into a solution of potass, the bromide will be formed; by evaporation it becomes white, and crystallizes in cubes. It may be made also by decomposing the bromide of zinc by carbonate of potass. This latter method is preferable, as by the former the *bromate* of potass is often produced.

987. *Bromide of sodium.*—Mix together bromine and sodium; they will unite with energy, and form the bromide of sodium.

988. Bromides of the other metals, may be procured by the addition of hydrobromic acid to a solution of their salts, or by adding an oxyde of the metal to an ethereal solution of bromine. The bromides of numerous of the metals have not been examined at all, and those which are known to exist are of little general use.

FLUORIDES.

The combinations of fluorine with the elementary substances are very few, and those few comparatively little understood. The hydrofluoric acid and fluoboric acid have been already described, (*Ex.* 883 and 884.) No combination of fluorine with oxygen, nitrogen, or carbon is known, and those with the metals so difficult to procure, and of such little utility when procured, that we pass them over without further notice.

CARBURETS.

The carburets are a most important class of bodies, as among them are contained the gases used for illumination, steel, black lead, carbonic acid, and the choke damp of the coal mines; the fire damp also, and numerous other bodies, equally important.

Carbonic oxide. See *Gases.*

Carbonic acid gas. See *Gases.*

Carburetted hydrogen. See *Gases.*

Hydroguret of carbon. Olefiant gas. See *Gases.*

Bicarburet of hydrogen. See *Gases.*

Bicarburet of nitrogen. Cyanogen. See *Gases.*

Carburet of iron, plumbago, cast iron, steel, &c. Iron, during the process of smelting in the furnace along with charcoal acquires carbon, and becomes a sub-carburet. It may be either grey or white in color, and hence called grey cast iron and white cast iron; the latter of which is by much the harder, and more brittle of the two. The proportion of carbon is extremely small. The carbon may for the sake of experiment be removed from the cast iron, by imbedding it in powdered oxyde of iron, and exposing it to a red heat; by this means it becomes wrought or malleable iron. To convert it into steel, wrought or pure iron is imbedded in charcoal and submitted to heat, the iron imbibes a portion of the carbon, and acquires a blistered surface. It is in this state called *blistered* steel. This when drawn out into bars and beaten, forms *tilted* steel; when this last is broken up, heated, welded, and again drawn out into bars, it is *shear* steel. When tilted steel is fused with charcoal, &c., and poured into ingots, it constitutes *cast steel.* All these are carburets of iron, and the following table drawn up by Mr. Mushet, of the Royal Mint, shows the quantity of charcoal absorbed in making various kinds of steel and cast iron.

Charcoal absorbed.	RESULTS.
$\frac{1}{120}$	.. Soft cast steel.
$\frac{1}{100}$	.. Common cast steel.
$\frac{1}{90}$	.. The same but harder.
$\frac{1}{50}$	.. The same but too hard for drawing.
$\frac{1}{25}$	.. White cast iron.
$\frac{1}{20}$	.. Mottled cast iron.
$\frac{1}{15}$	.. Black cast iron.

SULPHURETS.

Sulphur combines with most other elements, forming various important and singular substances—as follows :—

Sulphur and oxygen. See *Ex.* 808, *&c.*

Sulphur and hydrogen. See *Gases.*

Sulphur and iodine. See *Ex.* 962.

Sulphur and bromine. See *Ex.* 984.

Sulphur and chlorine. See *Ex.* 894.

989. *Sulphuret of phosphorus*, or *phosphuret of sulphur.*—Put some shreds of phosphorus in a phial or flask, and with them about an equal quantity of pulverized sulphur—pour water upon this mixture, and put it over a lamp or on a sand bath; when the water arrives at a temperature sufficient to melt the phosphorus, the union of that with the sulphur will commence and continue until a perfect sulphuret is formed. This experiment requires caution, as at the time of union of the substances, if the heat be not very moderate, an explosion will probably ensue. This substance ignites with the least degree of friction, it may therefore be used to advantage in the manufacture of *lucifer* matches, and for this purpose, as the presence of oxygen is of little moment, it is only necessary to melt together 2 parts of sulphur to 3 of phosphorus, by putting them in a cup and immersing the lower part of the cup in boiling water, the water however not flowing into it. For the sake of safety it should be damped with weak gum water before applied to the matches. See *Ex.* 402. It must be kept in a stoppered phial, otherwise it becomes changed into phosphorous acid and deposits sulphur.

990. *Sulphuret of carbon.*—This is a remarkable substance, producing by its evaporation a greater degree of cold than any other body whatever. It may be made as follows :—An earthen tube, coated with clay, is to be passed through a furnace, as in the annexed cut. Into the tube are to be put several pieces of newly-made charcoal, arranged so as not to choke it up. To one end must be attached a bent glass tube, connected with a glass globe, having a funnel-shaped termination below, which dips into water contained in a bottle. Let the beak of a small retort containing sulphur be luted to the other end of the earthen tube, and underneath the retort place a lamp or furnace. Now set fire to the fuel in the larger furnace, and when the tube is red hot, kindle also the lamp under the retort. When converted by this means into vapor, the sulphur will combine with the carbon, and both will pass together through the tube, to be condensed by the water. This compound being heavier than water will sink in it, and it may be distinguished from the water by a slight milky appearance. When no more gas passes into the bottle, detach the apparatus, and pour what has been obtained into a retort containing dry chloride of calcium, and distil by a heat not exceeding 106°. By this distillation, pure sulphuret of carbon is obtained. This substance boils at 106°, and freezes at 60° below zero.

991. *Second method.*—Put into an iron bottle similar to that used for making oxygen, (see *Ex.* 205,) a mixture of 5 parts of sulphuret of iron and 1 of powdered charcoal. Raise the retort to a red heat, when the sulphur will leave the iron and attach itself to the charcoal, forming the sulphuret of carbon, which may be collected by having a tube attached to the retort, and dipping at the farther end into a bottle of water.

992. *Water frozen by its evaporation.*—Wrap round a phial half filled with water, a piece of linen-rag, moistened by sulphuret of carbon, this will evaporate so quickly, that the water will speedily be frozen. The volatility of this liquid is so great, as to abstract almost instantaneously, a great quantity of heat from the water.

993. *Sulphuric acid may be frozen.*—Half fill a phial with sulphuric acid, and surround it with a rag moistened by sulphuret of carbon. The acid will speedily be frozen.

994. *Evaporation of sulphuret of carbon.*—Wrap round a spirit thermometer, a piece of rag, moistened by sulphuret of carbon. If the thermometer previously indicated the ordinary heat of the atmosphere, the fluid will speedily fall to zero; and if placed under the receiver of an air-pump, it will sink to 80° below zero.

Note.—It must be a spirit thermometer, and not one filled with mercury, for as this metal freezes at 40° below zero, it would of course be frozen long before the temperature had been reduced to the lowest point.

995. Add sulphuret of carbon to nitro-muriatic acid, a most singular and beautiful crystallized compound is produced, which Berzelius considered a compound of the hydrochloric, sulphurous, and carbonic acids.

996. *Sulphuret of potassium.* ($P+S=56.$)—To obtain this, pass hydrogen through a red-hot tube containing the sulphate of potass. This salt will thereupon be decomposed, and the oxygen of both the sulphuric acid and the potass uniting with the hydrogen to form water will liberate the sulphur and potassium to act upon each other. It is when thus prepared a dark, reddish brown substance, deliquescent in the air. When water is added it becomes the *hydrosulphuret of potassa;* a substance commonly employed as a test for the metals in solution. It is also the material from which sulphuretted hydrogen is most usually obtained. It may be made also as follows:—

997. *Hydrosulphuret of potass, to procure.*—Pass sulphuretted hydrogen gas through a solution of potass, the whole of the gas is retained and united with the potass, forming the hydrosulphuret, which therefore is a compound of sulphur and hydrogen united to the oxyde of potassium. It is however very doubtful if this be correct; the solution perhaps is that of the pure sulphuret of potassium, the sulphuretted hydrogen and potass being both decomposed, the hydrogen of the former uniting with the oxygen of the latter to form water, while the other elements combine to form the sulphuret. This opinion is supported by Berzelius.

998. *Hydrosulphuret of potassium.*—Professor Brande writes thus relative to this compound. "When potassium is heated in sulphuretted hydrogen it burns, and the gas diminishes in volume. During this action the potassium decomposes one proportional of the gas, and combines with its sulphur to form sulphuret of potassium, which uniting without decomposition with another proportional of the gas, forms a compound of sulphuret of potassium, 1 atom $=56$, and sulphuretted hydrogen, 1 atom or 17—together equal to 73. It is to such compounds that the terms sulphur salts properly applies." This hydrosulphuret yields with water a solution of bihydrosulphuret of potass; this when exposed to the air imbibes oxygen and becomes converted into hyposulphite of potass.

999. *Bisulphuret of potassium.* ($P+S\,2=72.$)—Heat together 4 parts of potassium and 3 of sulphur—the bisulphuret of potassium is the result; they unite with much violence, producing light and heat. According to the quantity of sulphur used, so the result will be either the sulphuret or the bisulphuret. See *Ex.* 421.

1000. *Sulphur and potassa.*—By fusing sulphur and potassa, a substance is obtained called from its color *livers of sulphur.* It is a compound of sulphuret or bisulphuret of potassium, and hyposulphite or sulphate of potass.

1001. *Another mode of combination.*—By the following method a purer sulphuret is obtained, the union of the oxygen of the potass with a part of the sulphur, to form hyposulphurous acid, not being assisted by heat. Rub together smartly in a mortar, 1 ounce of sulphur with 3 of potass; when properly combined, the color will be dark green, sulphuret of potass being formed.

1002. *Third method, still better.*—Put into a crucible, 1 ounce and ½ of sulphur with 2 ounces of dry carbonate of potass. Cover the crucible either by a lid, or with clay, so that there shall be a small aperture for the escape of the carbonic acid gas, which will quit the alkali when heated. The aperture is to be shut whenever a slip of paper dipped in lime water and held over it ceases to be covered with a film of carbonate of lime; this being a proof that all the carbonic acid has escaped. Let the whole now have a dull red heat, and then pour it out while fused on a marble slab. When sufficiently cool to handle, inclose it in a well-stopped phial.

1003. The same is obtained by boiling sulphur in a solution of potass. This is when first made the bihydrosulphuret of potassa, but soon changes into the sulphuret of potassium.

Sulphurets of soda and lime. The remarks on the sulphurets of potassium, apply to those of soda and lime.

1004. *Sulphuret of barium.* ($B+S=85.$) "Mix sulphate of baryta in fine powder into a paste with an equal volume of flour; place it in a crucible, on which a cover is to be luted, and expose it to a white heat for an hour or two, raising the temperature slowly. On pouring hot water on the ignited mass, the sulphuret of barium is dissolved, and may be separated from undecomposed sulphate and excess of charcoal by filtration."—*Turner's Chemistry.*

Sulphuret of strontium. ($St+S=60.$)—made as the last.

1005. *Sulphuret of magnesium* cannot readily be obtained. Berzelius states, that sulphate of magnesia decomposed by an aqueous solution of sulphuret of barium yields a precipitate of sulphate of baryta, and a solution of sulphuret of magnesium.

1006. *Sulphuret of manganesium.*—Perform *Ex.* 1002, with protosulphate of manganesium and ⅛ its weight of charcoal, a pure sulphuret of the metal will be obtained.

1007. *Sulphuret of iron, protosulphuret of iron.* ($Fe+S=44.$)—So great is the affinity between sulphur and iron, that this sulphuret, not only exists abundantly in nature under the name pyrites, but may be made by numerous methods, one of which is described in *Ex.* 11. Other combinations are as follows :—

1008. *Imitation of the natural sulphuret or iron pyrites.*—Weigh 1 oz. 4 drams of iron, and 32 grains of sulphur. Put the sulphur into a clean crucible, and when fused, put the iron filings in. These substances will unite into a body of the lustre of pure gold. If the crucible be left to cool a little ; and if when a crust is formed, the bottom be broken off, a cubical crystalline structure will be displayed.

1009. *Imitation of the radiated pyrites, or bisulphuret.*—Melt together in a crucible, 3 ounces of iron filings, with 1 ounce 6 drams of sulphur. The crucible is to be set aside, and when cold, if the mass be broken, it will be found to be brittle, to have a radiated appearance, and dull yellowish or grey color, without much lustre and magnetic. Nodules of this variety of sulphuret are very frequently found scattered over the downs and fields in many parts of the country, and are called, from their erroneously attributed origin, thunderbolts.

1010. *Artificial volcano.*—Mix 28 pounds of sulphur and 28 pounds of iron filings together, and add as much water as will form the whole into a paste ; bury the mass about 2 feet below the surface of the earth, and in twelve or fourteen hours so much heat will be generated as to swell the earth, and cause an artificial volcano, throwing up whatever impedes its progress, and scattering round ashes of a yellowish and black color. To succeed in this experiment, advantage should be taken of warm weather, (in the months of June, July, or August,) and after the tenth hour of burying the mass, care must be taken not to approach too near its situation. In this experiment, the air being excluded, the iron is the medium of decomposition. The heat of the situation permits the iron filings to attract the oxygen of the water to itself ;—in doing this the latent caloric of the oxygen combines with the hydrogen and sulphur, and produces the flames, which having the power of repulsion or of dilating bodies, swell and burst the earth, and the volcanic matter which is the residuum of combustion is thrown out.

1011. *Sulphuret of zinc, blende, black Jack.*—It may be formed artificially by melting oxyde of zinc with sulphur. The following which applies to numerous other metals is a beautiful experiment :—

1012. Mix together zinc filings and powdered sulphuret of mercury, (vermillion) throw a little of this mixture into a red hot crucible. The mercury is revived, and the zinc and sulphur unite together with much brilliancy.

1013. Drop a little powdered sulphur on to red hot zinc, when they will unite with energy, forming as in the other instances the sulphuret of the metal.

1014. Into a solution of sulphate of zinc, pour some water impregnated with sulphuretted hydrogen gas, and stir the mixture. A yellowish white precipitate of the sulphuret will fall down.

1015. *Protosulphuret of tin.*—Into a wine glass containing a little dilute chloride of tin throw a small piece of sulphuret of potass. The sulphuretted hydrogen formed by the decomposition of the water will deposit the protosulphuret of the metal.

1016. *Bisulphuret of tin, aurum musivum or Mosaic gold.*—If 2 ounces of sulphur and 2 ounces of oxyde of tin are put into a retort, and submitted to a considerable heat until the oxygen is driven off from the tin, with part of the sulphur in the form of sulphurous acid, a beautiful yellow scaly substance having a metallic lustre like gold will remain. This has been termed aurum musivum, or Mosaic gold, but it is really a sulphuret of tin, provided the sulphur be not sublimed ; if this be the case, more sulphur must be added, and the whole again fused. It is probable that this was one of the substances which the alchemists of the middle ages were enabled to impose on their credulous contemporaries as transmuted gold.

The following methods are to be preferred :

1017. Take 12 ounces of tin, and amalgamate it with 7 ounces of mercury ; reduce it to powder and mix with it 7 ounces of flowers of sulphur, and 6 ounces of sal ammoniac, and put the whole in a glass mattrass placed in a sand heat. Apply a gentle heat till the white fumes abate, then raise the heat to redness, and keep it so for a due time. On cooling and breaking the mattrass, the bisulphuret of tin is found at the bottom. The use of the mercury is to facilitate the fusion of the tin and its combination with the sulphur ; while the sal ammoniac prevents such increase of temperature as would reduce the tin to the state of protosulphuret. *Aurum musivum* is an inferior kind of *bronze* powder, its chief use at present is to bronze the surface of plaster of Paris figures, &c.

Sulphuret of cobalt.—Fuse together the metal and sulphur as in *Ex.* 1013.

1018. *Sulphuret of nickel.*—Fuse as in the last experiment, or else add a piece of the sulphuret of potassium to a solution of one of the salts of nickle.

1019. Throw a few grains of the sulphuret of nickel on to a red hot iron plate, it will burn and throw out brilliant sparks.

1020. ***Sulphuret of copper, copper pyrites.*** —This sulphuret cannot be formed by fusion, but it is thrown down when sulphuretted hydrogen is passed through a solution of protoxide of copper, the precipitate is at first brown, but becomes black, and when dried assumes a greenish hue. Copper pyrites or yellow copper ore is a mixture of the sulphuret of copper and that of iron.

1021. ***Sulphuret of lead.***—Into a diluted solution of acetate of lead, (sugar of lead) drop a small piece of sulphuret of potassium. Sulphuretted hydrogen will be produced by the decomposition of the water, a portion of the sulphur remaining to unite with the lead and form the sulphuret, which is of a black color. It may also be formed by fusing sulphur with the metal. The native sulphuret of lead is called ***Galena.*** See ***Lead.***

1022. ***Sulphuret of antimony*** varies somewhat in its composition, sometimes containing the protoxyde also, as in the *glass* of antimony prepared for medical purposes, thus. First, the metal is fused with sulphur; this forms the sulphuret; if sulphur be in excess it forms the ***sesqui-sulphuret.*** The heat being continued, the sulphur evaporates, and oxygen is absorbed; by increasing the heat the whole fuses into the ***glass of antimony*** a brown transparent substance, which is a compound of the protoxyde and the sulphuret; if much of the latter be present, it forms the ***saffron*** of antimony, ***crocus metallorum,*** or liver of sulphur.

1023. ***Kermes mineral, hydrosulphuretted oxyde of antimony.***—Fuse together equal parts of sulphuret of antimony and potass. Powder the mass when cold and boil it in 10 times its weight of water. Filter while hot. Kermes mineral will be afterwards deposited as a precipitate. The liquor must then have sulphuric acid added to it, which will throw down a beautiful orange-colored pigment, called golden sulphur of antimony.

The native sulphuret of antimony is often used in fireworks to communicate bright white sparks of fire.

1024. ***Sulphuret of bismuth.***—Throw bismuth in powder into melted sulphur, and fuse them together. It is of a blueish color, and metallic lustre.

1025. ***Sesqui-& protosulphurets of arsenic, orpiment, realgar, &c.***— Melt together in a crucible equal parts of arsenic and sulphur. This is a beautiful red crystalline substance used as a pigment, and well-known by the name of ***orpiment;*** also by a greater quantity of arsenic the result obtained would be the protosulphuret, commonly called ***realgar.*** King's yellow is also a pigment of the same kind, the color of the combinations of sulphur and arsenic depending entirely upon the proportions of materials and upon the manufacture.

1026. ***White fire for rockets, &c.***—Pulverize and mix intimately together 24 parts of saltpetre, 7 of sulphur, and 2 of realgar. This burns with a beautiful white light.

1027. ***Protosulphuret of mercury, Ethiops mineral.*** ($\mathrm{Hyd}+\mathrm{S}=216$.)—Triturate in a mortar equal parts of sulphur and mercury, they will unite and form a black or protosulphuret of the metal.

1028. ***Second method.***—Pass a stream of sulphuretted hydrogen through a dilute solution of the protonitrate of mercury. The protosulphuret wlll be thrown down.

1029. ***Bisulphuret of mercury, vermillion.*** ($\mathrm{Hyd}+\mathrm{S}=232$.)—Take of the black protosulphuret and expose it to heat in a crucible, it will gradually become changed into a red mass of the well-known pigment vermillion.

1030. ***Field's extract of vermillion.***—When vermillion is ground up with water and allowed to stand for a few minutes, it separates into 2 distinct portions, the one floating over the other forming a kind of cream, of a fine orange color. Mr. Field has ingeniously separated the two, the latter of which he has introduced as a pigment under the above name.

1031. ***Sulphuret of silver.***—Put a ladle containing sulphur upon the fire, and when vapor arises from it, hold over it, (by means of an iron tongs or forceps.) a piece of silver; the silver will be quickly blackened, or encrusted with a coat of sulphuret of silver. This is the mode imputed to the Jews for making the silver coin of these realms less troublesome to carry. The crust or sulphuret, when in considerable quantity, is afterwards exposed to a strong heat, whereby the sulphur is driven off, and the silver is revived. This piece of Jewish ingenuity is only discoverable by the loss of weight in the coin, as the impressions are as marked as ever:—the sulphuret being struck off quite clean by a smart blow of a hammer upon an anvil. In making sulphur coins, &c., the silver money in the pocket generally blackens, from imbibing the fumes of sulphur.

1032. ***Sulphuret of gold and of platinum.*** —Pass a stream of sulphuretted hydrogen gas through a solution of platinum or gold in nitro-muriatic acid. A black precipitate of sulphuret of platinum or gold will fall down. This powder may be obtained free by filtration.

PHOSPHURETS.

There are few of the phosphurets of practical utility, though one or two of them present curious phenomena, particularly phosphuret of lime. The metallic phosphurets may be made, either by adding phosphorus to the melted metal, in which case explosions mostly occur, with a considerable extrication of light; or by heating a mixture of the metal or its oxyde with phosphoric acid and charcoal, as is shown in the following preparations. The combinations of phosphorus with the non-metallic elements have been already described, except phosphuretted hydrogen, for which see *Gases*.

***Ex.* 1033.** *To prepare phosphuret of copper.*—The copper is to be fused with 2 parts of phosphoric acid and $\frac{1}{12}$ of charcoal powder. The shavings of the metal are to be placed in strata, with the acid and charcoal powder, and the crucible exposed to a fire sufficiently strong to fuse the glass. There is thus formed phosphorus, the greater part of which burns, while the rest combines with the copper. When the crucible has cooled and is broken, the phosphorated copper is found in the form of a grey brilliant button under the glass, which has passed to a state of red enamel. By this operation it is increased in weight one-twelfth. The copper thus combined with phosphorus acquires the hardness of steel, of which it has the grain and color, and like it is susceptible of the finest polish; it can be easily turned, and does not become altered in the air. The copper emits no smell when rubbed. The dark red enamel which is formed in this experiment may be employed with advantage for porcelain and other enamels, as this red does not alter in the fire.

1034. *To prepare phosphuret of calcium.*—Coat with common clay, ¼ of an inch thick, a glass tube, closed at one end, 12 or 14 inches long, and about ½ an inch wide. With a knife cut off the coating for about an inch upwards, at the closed end, and put into the tube 2 drams of phosphorus, cut small. The pieces will remain at the bottom, and may be seen from without. Now fill the tube as far as ½ an inch from the top, with newly calcined lime, broken into pieces of the size of swan shot; and place a paper stopper rather loosely in the mouth of the tube, to prevent the access of air as much as possible. Now lay the coated part of the tube in a pan of red hot charcoal, or on a portable furnace, in such a manner that the uncoated end may remain out of the fire, and rather lower than the other extremity. When the lime becomes red hot, apply a lamp to the phosphorus end. This heat will sublime the phosphorus among the lime, with which in an ignited state it will unite, forming phosphuret of lime, a brown substance. When no more phosphorus remains, take the tube from the fire, and let it cool gradually, so as to prevent the glass from being broken. Preserve the phosphuret in a well-stopped dry phial.

1035. *Second method.*—The following method, given in "Silliman's Journal," we have tried with success:—

"I employ, (says Dr. Coxe,) 2 crucibles, the lower of the two has a hole bored through its bottom, and a test tube of a suitable size, luted in with clay; the phosphorus is then put in the test tube, the top of which is loosely covered with a piece of broken crucible, to prevent the small pieces of quick lime from running down into it. The lime is then put in, so as to fill this crucible, and partly fill the upper smaller one, which serves as a cover to it, and is luted in with some fine clay a little moistened. The cover has also a small hole at the top, to afford an outlet for the air, or volatilized phosphorus, if there should be occasion for it. The whole is now placed upon the grate of the furnace, with a test tube projecting through, and appearing below, and a charcoal fire kindled around it. The phosphorus may be kept cool by making the tube dip into the water, contained in a tin cup attached to the end of a stick. When the crucibles, and their contents, are thoroughly red hot, a chafing dish is substituted for the tin cup, and the phosphorus rising in vapor produces the desired change."

1036. *Third method.*—Heat any quantity of lime, broken in small pieces, in a crucible or ladle. When red hot, add to it half as much phosphorus, aad cover it down immediately close from the air.

1037. *Iuflammability of phosphuret of calcium.*—Throw a small piece of this phosphuret into a glass of water; it will rapidly imbibe part of the water, and give off phosphuretted hydrogen gas, the bubbles of which, as soon as they reach the surface of the water, will burst into flame, with a slight explosion, at the same time emitting beautiful rings of white smoke, which ascend slowly with a quivering motion, expanding at the same time.

1038. It is a common and amusing experiment to put a small piece of the phosphuret of calcium in a lump of sugar; when the sugar is put into a cup of tea, the liberation and combustion of the gas takes place, as in the last experiment, but with greater effect and rapidity, in consequence of the liquid being hot.

THE GASES.

The gases form a very numerous class of chemical bodies, and possess properties the most wonderful and opposite to each other. They possess weight, like other bodies—their specific gravities being ascertained by comparison with that of air, as those of liquids and solids are by the gravity of water. Many of the compound gases exhale peculiar odours. But the properties which best serve to distinguish them from each other are the relative powers which they possess in supporting combustion and animal life. Several of the gases are simple elements, and as such have been already described under the titles of oxygen, hydrogen, chlorine, and nitrogen. Others are so rapidly absorbent of water, and so well known when thus combined, that although really gases, yet they are ordinarily considered as liquid or solid. Of the former kind are hydrochloric acid, sulphurous acid, nitrous acid, ammonia, and some others. These last four are binary compounds, and so are also the important gases which follow :—

Euchlorine. See *Ex.* 766.

Ammoniacal gas. See *Ex.* 742.

Chlorous acid gas. See *Ex.* 774.

Nitrous acid gas. See *Ex.* 786.

Sulphurous acid gas. See *Ex.* 809.

Hydrochloric acid gas. See *Ex.* 859.

Hydriodic acid gas. See *Ex.* 869.

Hydrobromic acid gas. See *Ex.* 877.

Hydrofluoric acid gas. See *Ex.* 883.

Ex. 1039. *Nitrous oxyde. Protoxyde of nitrogen. Laughing gas.* ($O + N = 22$.)—This interesting compound is easily procured thus:—Put $\frac{1}{4}$ of a pound of crystals of nitrate of ammonia in a glass retort. Let the beak of the retort enter the lower hole of the gas holder, (described in page 33;) let the gas holder be previously filled with *hot* water. Then apply the heat of a lamp beneath the body of the retort. The salt will first melt, and afterwards boil. When it does so, nitrous oxyde gas will pass over into the gas holder, and passing through the water will become purified from chlorine or nitric acid with which it is often contaminated. When wanted for use it may be drawn off in the ordinary way, being careful to pour in *hot* water to the gas holder as the gas escapes. Cold water absorbs its own bulk of this gas, but hot water absorbs more; it is for that reason, therefore, that it must be used. It is of a sweet, pleasant, and peculiar taste and smell.

1040. *To try the purity of nitrous oxyde.*—In order that the water may have time thoroughly to absorb, the condensable gases, which may be united with the nitrous oxyde, the latter should not be used for some hours after having been made; its purity may then be ascertained by holding a lighted candle to the orifice of the gas holder, and suffering the gas to blow upon the flame. This will be much increased in size, and burn of a yellow color.

1041. *Does not long support animal life.*—Prepare a jar of this gas, and immerse in it a mouse or other small animal; at first it will appear lively, but afterwards very uneasy and languishing, and life will quickly become extinct.

1042. *Occasions intoxication.*—Fill a bladder, having a tube and stop-cock, with this gas. If the mouth be applied to the tube after the expiration of as much air from the lungs as possible, and this gas be repeatedly inhaled instead, a strange but very pleasant sensation will pervade the whole body: this will be accompanied by warmth at the chest and giddiness. The eyes of the person who has inhaled it will roll about wildly, and he will have every symptom of intoxication; still this intoxication will be different from that produced by ardent spirits, for the experimentalist will, as it were, be so much elated, as to give way to all manner of extravagant and violent actions and gestures; such as running, leaping, wrestling, boxing, dancing, reciting, whooping and holloaing.

Note.—It is rather singular that many have evinced, at this time, what were their general propensities at others. Some, for instance, will recite plays, whilst others are ready to knock the by-standers down. The experiment of inhaling this gas should be performed in a field, or in a large room, without furniture, that nothing may impede the extravagant motions of the *pro tempore* madman. Laughter is the most common effect, hence this gas is often called the *laughing gas*. It should not be administered to persons having a determination of blood to the head.

1043. *Nitrous oxyde supports combustion more brilliantly than atmospheric air.*—Introduce a suspended taper after the flame has been blown out but with the wick still red into a jar or bottle filled with this gas. It kindles into a flame, and burns brilliantly.

1044. *Burning a taper.*—Prepare a jar of nitrous oxyde gas, and immerse in it a lighted taper; the flame will instantly be rendered more vivid, and as the taper burns, slight detonations will be heard. When the gas has been nearly expended, the external film of flame will be of a very beautiful azure hue.

1045. *Burning of charcoal.*—If a piece of red-hot charcoal be introduced into a jar of nitrous oxyde gas, it will burn with almost the same brilliancy that it does in oxygen gas.

1046. *Burning of iron-wire.*—Attach a small piece of phosphorus to a spiral wire, similar to that used for combustion in oxygen gas; set fire to the phosphorus, and when in a state of inflammation, introduce it into a large jar of nitrous oxyde gas; a very beautiful scintillating combustion, with much splendour will take place.

1047. *Burning of phosphorus.*—Immerse a piece of ignited phosphorus in a jar of nitrous oxyde gas; it will burn remarkably quick, and with astonishing splendour. If a small piece, of double the size of pin's head, be put in a platinum spoon immersed in the gas, and a thick iron-wire heated to whiteness be brought in contact with it, an explosion will be the consequence.

1048. *Combustion of sulphur.*—Dip a long slip of wood in melted sulphur, so that one-half and upwards may be covered. Light it, and whilst burning with a weak blueish flame, introduce it into a jar of nitrous oxyde gas: the flame will be instantly extinguished. Withdraw the match, inflame it again, and let it burn for two or three seconds until the flame be vivid, then immerse it once more. Instead of extinction, the flame will be now kept up with great splendour. It will be of a delicate red color.

1049. *Zinc filings burn in.*—Put some zinc filings into a platinum spoon; and with them a small piece of phosphorus; set the phosphorus on fire, and immediately plunge the whole into a jar of nitrous oxyde gas. Combustion will be communicated to the zinc, which will accordingly give out a greenish flame.

1050. *Beautiful combustion of Homberg's pyrophorus.*—Pour some Homberg's pyrophorus into a jar of nitrous oxyde gas; as it descends, it will appear to be transformed into a stream of fire.

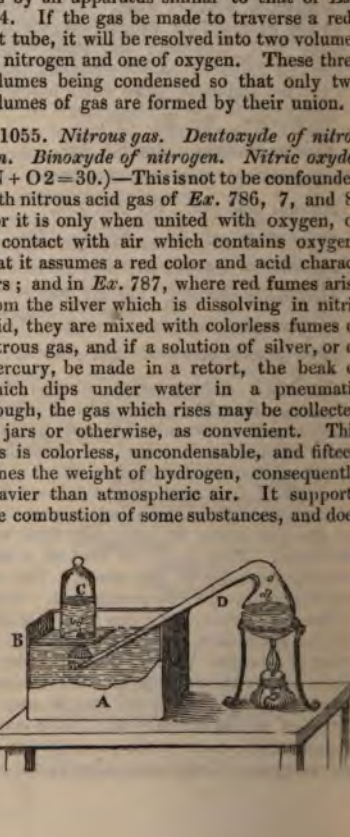
1051. *Nitrous oxyde explodes when inflamed with hydrogen.*—Fill a small stout wide-mouthed phial with equal parts of hydrogen and nitrous oxyde gases: before the phial is removed from the shelf, wrap round it a piece of cloth, or a pocket-handkerchief. Now lift it up quickly, and present the mouth to the flame of a candle; a loud explosion will be the consequence.

1052. *Explodes when inflamed.*—Half fill a jar with nitrous oxyde gas, fill the other half with hydrogen gas, and fill a bladder from the mixture. Attach a tobacco-pipe to the bladder, and prepare some soap lather. Dip the bowl of the pipe in the lather, form bubbles, and set fire to them when they have ascended a little way: they will explode with a loud report.

1053. *Combustion with phosphuretted hydrogen, attended by explosion.*—Prepare a jar of nitrous oxyde gas, and pass up into it a few globules of phosphuretted hydrogen gas one at a time; they will explode the instant they come in contact with the other gas, exhibiting a very bright flame. Phosphate of ammonia will be the result of this combustion; for the oxygen of the nitrous oxyde, having combined with the phosphorus to form phosphoric acid, leaves the nitrogen to combine with the free hydrogen, and thus form ammonia. But these two substances being unable to retain their gaseous form separately in the same vessel combine and form phosphate of ammonia.

1054. *Composition of nitrous oxyde.*—This is shown by the decomposition of the gas by an apparatus similar to that of *Ex.* 754. If the gas be made to traverse a red-hot tube, it will be resolved into two volumes of nitrogen and one of oxygen. These three volumes being condensed so that only two volumes of gas are formed by their union.

1055. *Nitrous gas. Deutoxyde of nitrogen. Binoxyde of nitrogen. Nitric oxyde.* $(N + O2 = 30.)$—This is not to be confounded with nitrous acid gas of *Ex.* 786, 7, and 8. For it is only when united with oxygen, or in contact with air which contains oxygen, that it assumes a red color and acid characters; and in *Ex.* 787, where red fumes arise from the silver which is dissolving in nitric acid, they are mixed with colorless fumes of nitrous gas, and if a solution of silver, or of mercury, be made in a retort, the beak of which dips under water in a pneumatic trough, the gas which rises may be collected in jars or otherwise, as convenient. This gas is colorless, uncondensable, and fifteen times the weight of hydrogen, consequently heavier than atmospheric air. It supports the combustion of some substances, and does



not detonate with hydrogen, and is instantly fatal to animal life. The preceding shows a convenient arrangement of apparatus for the making of nitric oxyde.

1056. *Does not support animal life.*—Confine a mouse or other small animal in a jar of nitrous gas: life will immediately become extinct.

1057. *Inflamed charcoal burns in nitrous gas.*—Inflame a piece of charcoal, and immerse it by means of a wire in a jar of nitrous gas; a very brilliant combustion will be the consequence.

1058. *Homberg's pyrophorus burns in nitrous gas.*—Pour some of Homberg's pyrophorus into a jar containing nitrous gas; a very beautiful stream of fire will be seen to flow to the bottom of the jar.

1059. *Nitrous gas does not support the combustion of a taper or candle.*—Immerse a lighted taper or candle in a jar of nitrous gas; it will be instantly extinguished. In the two foregoing and three following experiments, the substances employed are elevated to so high a temperature, as to separate the oxygen from the nitrous gas; it is not so with the flame of a candle, which cannot destroy the affinity which exists between the nitrogen and oxygen.

1060. *Phosphorus burns in nitrous gas.*—Set fire to a piece of phosphorus, and immerse it (in a platinum spoon,) in a jar of nitrous gas: a very brilliant combustion will now take place, and phosphorus acid will be formed, at the same time that nitrogen gas will be disengaged.

1061. *Hydrogen burns when mixed with nitrous gas.*—Fill a stout phial with nitrous and hydrogen gases in equal proportions, set fire to the gases at the mouth of the phial. Flame of a green color will pervade it.

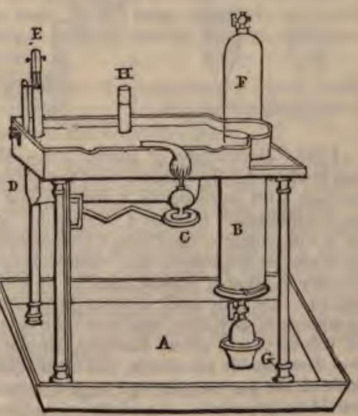
1062. *Sulphuretted hydrogen will burn when mixed with nitrous gas.*—Let a bladder be filled with $\frac{3}{5}$ of sulphuretted hydrogen gas and $\frac{2}{5}$ of nitrous gas. If soap-bubbles are blown with this compound, they will explode and burn with a light-green flame, when a lighted candle is brought in contact with them. If these proportions are mixed in a jar and inflamed, a greenish flame will pervade the whole of the vessel.

1063. *Absorbed by solutions of iron.*—Make a solution of green vitriol, (sulphate of iron,) and pass a little of this gas through it; the solution, before of a light green transparent color, will become quite black and opaque; the gas at the same time being absorbed in large quantity. If any nitrous oxyde or nitrogen are present, they will not be absorbed; therefore this experiment will test the purity of the gas.

Union of nitric oxyde and oxygen, forming nitrous acid. See *Ex.* 786.

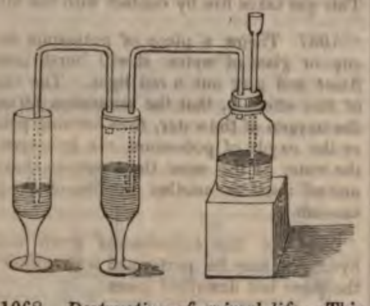
1064. *Sulphuretted hydrogen gas, hydrothionic acid, hydrosulphuric acid.* ($S + H = 17$)—There are various ways of making this interesting gas; among the simplest are the following:—Put 1 ounce of sulphuret of iron into a tubulated retort, and pour over it an ounce of diluted sulphuric acid. The sulphuric acid, in attacking the iron, will receive the assistance of the oxygen of the water (by which it was diluted) in oxydising the metal before it is converted into sulphate of iron. The hydrogen of the water will thus be free to combine with the sulphur. The sulphuretted hydrogen may be received in the common way in a mercurial pneumatic apparatus, or in a bladder attached to the beak of a retort.

1065. *Mercurial pneumatic trough.*—It is necessary to be observed, that all gases readily absorbable by water, should be received over *mercury*, in a trough made for the purpose of containing from 12 to 20 pounds. These troughs, which are made of cast-iron, are so contrived as to render this small quantity of the fluid metal sufficient for experimental purposes. The annexed cut exhibits the mercurial trough in its most improved condition. A is a varnished tin tray to prevent a waste of any mercury which may overflow. G a retort, with tube and stop-cock, communicating with the conductor B, and the bell-glass F, for the reception of the gas. C and H are also a retort and receiver for preparing the gas on a small scale. D is the trough containing the mercury; and E is a detonating tube for the explosion and condensation of the gases.



1066. *Second method.*—The following is M. Gay Lussac's method of preparing sulphuretted hydrogen gas:—"The way I obtain this gas is, to mix 2 parts of iron filings with 1 of flowers of sulphur, then to put it into a mattras with as much water as will give it the consistence of soup, and heat the vessel to promote the union of the sulphur and iron, which soon shows itself by a great disengagement of heat, and a black color spreading through the whole mass. Then sulphuric acid diluted with 4 times its volume of water, disengages the sulphuretted hydrogen with nearly as much rapidity as from an alkaline hydro-sulphuret. The mixture should never be prepared before the gas is to be obtained."

1067. *Impregnation of water by sulphuretted hydrogen gas.*—Put some sulphuret of iron into a tubulated retort, and connect it with a receiver and Woolfe's bottle, containing distilled water (see *Ex.* 285): pour diluted sulphuric acid into the retort. The acid will form with the iron, sulphate of iron, and the sulphuretted hydrogen will be set free to be absorbed by the water in the bottles. The water will absorb about 3 times its own bulk of this gas, and will possess its disagreeable smell. The Harrowgate and other waters are natural compounds of this kind. Water may be impregnated in the same way, by pouring diluted muriatic acid over sulphuret of potass or soda, in an apparatus similar to the following, which may be made of common ale glasses or phials—corks being put into all but the last phial.



1068. *Destructive of animal life.*—This gas is of so deadly a nature that the greatest caution must be observed in not inhaling it, as a combination of even a thousandth part of it with common air will be a fatal mixture. It is also so insinuating and instantaneous in its effects, that a person inhaling it would fall down instantly dead, without premonitory symptons of any kind, and without a chance of recovery. It gives, however, so strong and disagreeable an effluvia, that even a cubic inch of the gas escaping in a large apartment would be apparent. Its odour may, therefore, be strongly perceptible without danger; indeed a mixture of atmospheric air and sulphuretted hydrogen would be extremely disagreeable, long before the atmosphere was fatally contaminated; yet for all this the head should not be held over the beak of a retort in which the gas is generating. This gas is a valuable test for the metals; its properties as such will be considered hereafter.

1069. *Union of the gas with sodium and potassium.*—Heat a globule of sodium or potassium (in an iron spoon) in a jar of sulphuretted hydrogen gas. A very beautiful combustion will take place, and hydrogen gas will be evolved.

1070. *Combustibility of.*—Fill a bladder, having a stop-cock with this gas: When it is to be inflamed, open the cock, and light the gas as it issues forth. It will burn with a flame varying in color from bright yellow to blue, reddish and violet.

1071. *Combustion of with oxygen.*—Fill a bladder having a pipe or stop-cock, with $\frac{2}{5}$ of sulphuretted hydrogen, and $\frac{3}{5}$ of oxygen gas: dip the pipe in soap-suds, and blow bubbles by pressing the bladder between the hands; the bubbles will ascend, and may be inflamed by a lighted candle. These bubbles detonate at the time of inflammation. The products of this combustion are water and sulphurous acid.

Combustion of with nitrous gas. See *Ex.* 1062.

1072. *To detect sulphuretted hydrogen.*—It was observed, in *Ex.* 1067, that Harrowgate water obtained its peculiar properties from the presence of sulphuretted hydrogen. The ready union of silver and sulphur was also shown in *Ex.* 1031. This metal indeed affords a certain proof of the presence of sulphuretted hydrogen. Accordingly throw a shilling into a glass of Harrowgate water; in a few seconds it will be rendered quite black, that is, covered with a coat of the sulphuret. Nearly the same effect will take place when a silver spoon is used in eating an egg.

1073. *Phosphuretted hydrogen gas.*—Put into a small retort $\frac{1}{2}$ a dram of phosphorus in small pieces, and a dram of zinc filings. Pour over these 3 drams of sulphuric acid diluted with 6 drams of water. Put the beak of the retort under a bell-glass in a pneumatic trough; phosphuretted hydrogen gas ascending will displace the water, and fill the glass. Several glasses may be filled from this quantity; one of these glasses should have a stop-cock, by which bladders may be filled, or by which it may be allowed to issue for combustion in atmospheric air. In this experiment, the zinc and acid decompose the water, the oxygen of which unites with the zinc, while the hydrogen being set free combines with the phosphorus, and both are evolved in the gaseous form.

1074. *Second method.*—Drop into a small retort ½ of an ounce of phosphorus cut small; then completely fill it, neck and all, with a moderately strong solution of potass or a mixture of lime and water; closing the end with the finger, immerse it under the shelf of the pneumatic trough, and place a jar full of water over the hole of the trough. Next apply the heat of a lamp beneath the phosphorus, this will soon boil, and phosphuretted hydrogen arise from it, which will be received in the jar. The gas thus obtained is more pure than by the former experiment.

1075. *Third method.*—"Fill a small retort with water slightly acidulated with hydrochloric acid, then throw into it a quantity of phosphuret of calcium in lumps. Plunge the beak of the retort under water, and place over it an inverted jar filled with that liquor. Phosphuretted hydrogen will be liberated in the proportion of about 70 cubic inches of gas to ½ an ounce of the phosphuret."—*Thompson's Chemistry.*

1076. If the jar to hold the gas be dispensed with, the bubbles as they arise and come in contact with the air will explode, and throw off beautiful white rings of smoke, as in *Ex.* 1037. This smoke is luminous in the dark.

1077. If the gas be received in a jar containing oxygen, the inflammation of the rising bubbles will be of a white color, much more brilliant than in common air, and explode with a louder report.

1078. If the gas be received in a jar of nitrous oxyde, they burn with a beautiful greenish blue flame.

1079. A similar experiment may be tried with a jar of chlorine; upon the phosphuretted hydrogen being admitted, it explodes with a green light, forming hydrochloric acid and perchloride of phosphorus.

1080. Lift up the jar when filled with phosphuretted hydrogen by the process of *Ex.* 1073; immediately upon the atmospheric air being admitted, the whole will explode, with a blueish white flame and strong scent; metaphosphoric acid and water being formed at the same time.

1081. If a glass retort or jar filled with this gas be carried into a dark room, and air carefully and slowly admitted to the gas; the combination of the two will be gradual, and present a very beautiful phosphorescence.

1082. *Arsenuretted hydrogen.*—To an alloy formed of 1 part of metallic arsenic, introduced into a retort, add hydrochloric acid and apply heat; the arsenuretted hydrogen will escape. It may be collected over water in the same manner as hydrogen. Great care must be taken not to inhale this gas; it proved fatal to the late M. Gehlen, a continental chemist.

1083. *Second method.*—Put 4 drams of zinc filings into a small retort, with 2 drams of filings of arsenic, and pour over them 1 ounce of diluted sulphuric acid; if the beak be put under a bell-glass on the pneumatic shelf, arsenuretted hydrogen gas will ascend and displace the water. Here the acid in acting upon the zinc decomposed the water used as a diluent, the oxygen of which oxydizes the metal, whilst the hydrogen is set free to unite with the arsenic. This gas burns with a very delicate bright flame.

1084. *Third method.*—Make an alloy of equal parts of arsenic and zinc, reduce this alloy to small fragments, and add to it strong hydrochloric acid. The gas will be liberated.

1085. *Hydrozincic gas.*—This, which is supposed to be common hydrogen gas, holding in combination with it minute particles of zinc—is made by adding dilute sulphuric acid to pieces of zinc in a bottle, as in *Ex.* 245.

1086. *Potassiuretted hydrogen.*—Pass potassium and hydrogen both together through a gun-barrel previously brought to a white heat, the hydrogen will unite with the potassium, and pass off as potassiuretted hydrogen. This gas takes fire by contact with the air.

1087. Throw a piece of potassium on a cup or glass of water, it will burst into a flame and give out a red light. The cause of this effect is, that the potassium attracts the oxygen of the water, thus forming potass or the oxyde of potassium, the hydrogen of the water at the same time escapes, having united itself to another portion of the potassium.

Most of the experiments given under hydrogen may be performed with either of the three last described gases.

1088. *Carbonic oxyde.* (Car + O = 14.) *Gaseous oxyde of carbon.*—Heat in an iron retort a mixture of chalk and charcoal, or else chalk and iron filings. The chalk being by this means decomposed, will yield up its carbonic acid. The effect of the iron in the one case, and of the charcoal in the other, is to absorb a portion of oxygen from the carbonic acid, and thereby to change it into carbonic oxyde.

1089. Equal parts of oxyde of zinc and charcoal may be used.

1090. Still preferable is a mixture of equal parts of carbonate of barytes and iron filings, placed in an iron or earthenware retort.

1091. *Another method.*—The most convenient method to make carbonic oxyde is to heat crystallized oxalic acid with sulphuric acid in a retort, collecting the gases evolved in a pneumatic trough filled with lime water. 500 grains of oxalic acid, and 6 or 8 drams by measure of sulphuric acid yield a large quantity of gas. The heat must be applied cautiously and gradually, and the retort not be above one-third full. The more acid is used the more rapidly will the gas be disengaged.

1092. *To purify carbonic oxyde.*—Let the gas be made to pass through *lime* water; this will absorb any carbonic acid gas which it may at first contain.

1093. *Extinguishes flame, &c.*—Immerse a lighted taper in carbonic oxyde gas, the flame will be immediately extinguished, but the gas will take fire and burn with a blue lambent flame, at that part where it is in contact with the atmosphere.

1094. Instead of the taper of the last experiment, immerse a red hot iron wire into a jar of the gas; this will be sufficient to inflame it, when it will burn as before. Oxygen being absorbed during combustion, the carbonic oxyde becomes changed into carbonic acid gas.

1095. Mix together equal portions of nitrous oxyde and carbonic oxyde; upon applying flame, the gases will unite with explosion, the result will be precisely equal quantities of carbonic acid gas and nitrogen, showing that the carbonic oxyde has exactly combined with the oxygen which formed part of the nitrous oxyde. No change of bulk takes place in this experiment.

1096. Dip a piece of litmus paper, or else pour a little water rendered blue by red cabbage into a jar of carbonic oxyde; no change of color will take place, showing that the gas has not acid properties, like those of carbonic acid gas.

1097. *Fatal character of.*—Drop a small animal into a jar of this gas, and its life will be immediately extinct.

1098. *Effects on respiration.*—Professor Higgins, of Dublin, wishing to compare the effects of carbonic oxyde, with those of the nitrous oxyde by inspiration, procured some for that purpose. Having exhausted his lungs of atmospheric air, he made three or four deep inspirations of the gas. The effects were an inconceivably sudden deprivation of sense and volition. He fell supine and motionless on the floor, and continued in a state of total insensibility for nearly half an hour almost lifeless, pulsation being nearly extinct; several medical gentlemen being present to witness the experiment, various means were used for his restoration, but without success. At last the introduction of oxygen gas, by compression into the lungs, was suggested. A very rapid return of animation ensued, though accompanied by convulsive agitations, excessive headache, and quick irregular pulsation; and for some time afterwards total blindness, excessive sickness and vertigo, with alternations of heat and shivering cold, were painfully experienced. This state was succeeded by an uncontrolable propensity to sleep, which was broken and feverish. An emetic of tartarized antimony finally removed those alarming symptoms, and the only unpleasant effects felt on the ensuing day were those occasioned by the fall. [Although this experiment is too hazardous for repetition, still it is a proof of the efficacy of oxygen gas, which may arise in cases of suspended animation proceeding from choke damp, &c. Another gentleman had respired the gas for a few moments previous to Professor Higgins, and suffered much from the attempt.

1099. *Carbonic acid, fixed air, aerial acid, choke damp, &c.* ($\mathrm{Car} + \mathrm{O}\,2 = 22.$)—For all the purposes of experiment, carbonic acid may be conveniently procured by the action of hydrochloric acid upon white marble, which in small fragments is introduced into a two-necked bottle A, and covered with water; hydrochloric acid is then slowly poured down the funnel B, which causes an immediate effervescence, and the gas passes through the bent tube C into the inverted jar D. When the action ceases, it may be renewed, by the addition of fresh acid, until all the marble is dissolved. The gas is heavier than atmospheric air.

1100. *The result of combustion.*—Fasten a lighted taper to a piece of cork, float the cork in water, and cover it over by a glass closed at the top, such as a tumbler turned upside down: the burning taper will consume the oxygen of the air beneath the tumbler, and instead of it deposit carbonic acid gas. This will be gradually absorbed by the water. See also *Ex.* 222.

Product of the combustion of the diamond. See *Ex.* 347.

1101. Into a glass tumbler put ½ an ounce of powdered chalk, and add to it a dram of sulphuric acid; very little agitation will take place, owing to the want of power which the acid has to diffuse itself among the particles of chalk. But if the tumbler be one-third filled with water, the acid will hastily combine with it, and thus becoming diluted, will present so large a surface to the chalk, as to attack it at all points, seizing the lime, and driving off the carbonic acid with great effervescence. By holding the nose over the tumbler, the peculiar odour of the carbonic acid may be perceived. When the effervescence is at an end, a white powder will subside to the bottom of the tumbler, which is sulphate of lime.

This experiment, and also that numbered 14 in page 7, shows the formation of the numerous summer drinks called soda water, ginger beer, &c. Receipts for making these, if not necessary to show the nature of carbonic acid gas, will at least not be ill-timed, nor it is hoped altogether useless.

1102. "*Ginger beer in bottles.*—Put into any vessel, 1 gallon of boiling water, 1 pound of common loaf sugar, 1 ounce of best ginger, (bruised) 1 ounce of cream of tartar, or else a lemon sliced. Stir them up until the sugar is dissolved, let the whole rest until about as warm as new milk, then add 1 tablespoonful of good yeast, poured on to a bit of bread put to float on it. Cover the whole over with a cloth and suffer it to remain undisturbed 24 hours. Then strain it, and put into bottles, observing not to pour more in than will occupy three-quarters of their capacity, or as we usually say three-quarters full, cork the bottles well and tie the corks, and in two days in warm weather it will be fit to drink. If not to be consumed till a week or fortnight after it is made, ¼ of the sugar may be spared. The above quantity of ingredients will make 18 bottles, and cost ten-pence.

1103. "*Common ginger beer.*—That common drink sold in the streets is made with raw sugar or treacle, ½ a pound to the gallon of water, the ginger ground and without the acid, costing one farthing per bottle.

1104. "*Lemonade in bottles.*—This differs in no degree in manufacture from ginger beer, the ginger being left out, and 18 drops of the essence or of the oil of lemon being first ground up with the sugar,—the essence is the same as the oil of lemon, but mixed with spirits of wine; it therefore unites readily with the other ingredients, and is more convenient in use.

1105. "*Soda powders* are tartaric acid and carbonate of soda. Procure an ounce of each, and divide it into 16 portions, wrap up the acid in one colored paper, and the soda in another, (merely for the sake of distinction when used,) dissolve one of each kind in ½ a tumbler of water, mix the two solutions together and take it immediately.

"The above method of mixing is very inconvenient, because the effervescence is so rapid that it overflows the glass, it is better first to dissolve the soda in all the water, then add the acid in powder and drink immediately. Using equal quantities of each material, the drink will be slightly acid, which to most persons is agreeable. Citric acid may be used instead of the tartaric, and will be found an improvement.

1106. "*Soda-water in bottles.*—Dissolve 1 ounce of the carbonate of soda in a gallon of water, put it into bottles, in the quantity of a tumbler full or ½ a pint to each; having the cork ready, drop into each bottle ½ a dram of tartaric or citric acid in crystals, cork and wire it immediately, and it will be ready for use at any time.

1107. "*Lemonade powders.*—Pound and mix together ½ a pound of loaf sugar, 1 ounce of carbonate of soda, and 3 or 4 drops of the *oil* of lemon, divide the mixture into 16 portions, and use them instead of the soda alone, as recommended under soda water.

1108. "*Ginger-beer powders.* — Take away the oil of lemon from the former receipt, and substitute a few grains of finely powdered ginger, or else a few drops of the essence of ginger.

1109. "*Seidlitz powders.*—Take 1 dram, that is ⅛ part of an ounce, of bi-carbonate of potass, and 2 drams of tartarized soda, dissolved in a tumbler 3 parts full of water, add to this 1 dram of citric or tartaric acid, and drink while in a state of effervescence.

"In all the above receipts lemon juice may be used, 2 table spoonsful of lemon juice being equal to 1 dram of tartaric acid."—*Magazine of Science.*

1110. *Impregnation of water by carbonic acid.*—Of most of the above compositions, the efficacy consists in their being drunk previous to the carbonic acid flying off. Another class of them is formed by combining the gas with water, in which it is absorbable, forming, in proper language, ærated water, though commonly called *soda* water, and sold in bottles. There are various kinds of apparatus for this purpose; one of the most simple is that of Dr. Nooth's, represented on the following page.

The upper vessel E is shaped like a funnel contracted at the top, and covered by a stopper, which however does not fit tight; the middle vessel D fits into the lower one A, and a communication is made from one to the other by a tube C between them, which tube is perforated by holes so small, that gas will ascend through them, but water will not descend, (a piece of cane answers such a purpose). The lower vessel A contains chalk and water. To use the apparatus, fill B with water, then partly fill E also with water, and put them in their appointed places upon each other; then pour sulphuric acid into the orifice B, carbonic acid gas will rise, pass through C, and be absorbed by the water in D. When more gas arises than can be absorbed, its pressure above the surface of the water in D will drive a portion of that water up into the funnel at top E, and thus the safety of the apparatus is insured. When the ærated water is required for use, it is drawn off by the tap F.

The above apparatus is only calculated for an occasional supply of a small quantity of ærated water,—the following one is given in "Mackenzie's Chemistry."

According to the following figure, suspend an air tight barrel D, having a cock F, and a handle E, between two pillars; attach to one side a tube, having a cock C, passing through a varnished air tight bellows B, into a bottle A; the bottle has a stopper, and on the top of the bellows a weight is to be occasionally placed; the tube is to open into the bellows, and again further on into the barrel. When the apparatus is to be used, pour distilled or spring water into the bung-hole, until the barrel is half filled; then put in an air tight bung, and place over it a jointed hoop, which is to be locked by a linch pin to prevent the bung from being forced out by the elastic force of the gas. Now pour into the tubulure of the bottle some diluted sulphuric acid over a quantity of powdered carbonate of lime (chalk). The carbonic acid generated in the bottle will ascend through the tube into the bellows, which will rise from distension. When the bellows is full, the cock C is to be turned, and the weight is to be placed upon the top of the bellows, which will of course press the gas downwards through the tube into the barrel. As this gas is readily absorbable by water, that in the barrel will soon be impregnated by it; but more especially when the barrel is quickly turned. Glass bottles quickly filled with this carbonated water will preserve it good and pure for many months, if the corks are bound down by copper wire. Other liquors, such as spirituous, saccharine, and aromatic, are also impregnated by this gas. In the large way, these are saturated under a considerable pressure, which is reduced in part on the liquors being bottled. The decantation is effected by stopping the mouth of the bottle or jar with a perforated cork, leather, &c., through which the decanting tube passes, so that on opening the cock, the ærated liquor rushes into the bottle, till resisted by the condensation of the atmospheric air it originally contained; and a portion of carbonic acid gas is extricated during the effort. When full, the bottle may be withdrawn and stopped with ease, by letting off slowly a small portion of the fixed air contained before its removal. In some cases the decanting-cock is constructed so as to allow the stopper to pass into the bottle, &c., previously to its removal from the flat air-tight fitting; by which means the entire pressure may be retained.

We give one other method, and one which is in more common use than either of the above. A is a small strong cask with a funnel at the top and two pipes at the sides; all fitting air-tight, and furnished with cocks. The funnel at top, though not so represented, should extend beneath the surface of the liquor in A. The pipes mentioned extend to near the bottom of the side vessels, which also are furnished with funnels, the stems of which should likewise reach to near the bottom of the respective vessels. They have moreover a pipe each which dips beneath the liquor in them, and proceeds to the jets or cock at top. The apparatus from K upwards may be above a shop counter, the other part may be beneath the counter, or in a yard or adjoining apartment, and the stronger the vessels are the better will be the impregnation. The two sides of the apparatus are similar, one intended for soda water (so called), the other for ginger beer. If only one article be wanted, of course the one side of the machine may be omitted altogether. Its action is as follows :—Put into A 2 or 3 pounds or more of chalk, pour upon this a gallon of water, also half fill C with water, either pure or flavored with sugar, ginger, lemon, &c. Close the cocks I and G, and open that at B. Then pour sulphuric acid into the funnel F. This will act upon the chalk, and liberate the gas—which, when F is turned off, will pass into the water of C, where it will be absorbed, and after absorption has taken place will accumulate in the upper part of the vessel C, and exerting a pressure upon the liquid will drive it up the tube D, to the cock I, whence it may be drawn for use.

Note.—It is essential that no escape of gas should take place even when at a considerable pressure; also as the acid dissolves iron and zinc rapidly, and the carbonic acid acts readily upon copper, the vessels are better made of wood than metal. The tubes also are apt to leak at their joints by corrosion; to remedy this as much as possible they should be made of pewter, tin, or lead. It may be observed also, than when enough gas has been liberated to occasion a pressure in the vessel A, no more gas will be liberated until that pressure is removed; thus if the ærated water should not be drawn off as soon as ready, there will be very little, if any, wasteful expenditure of the materials.

1111. *Carbonic acid arises from fermentation.*—It is this gas which gives the sparkling to champagne, cider, and other fermented liquors; this is proved by holding a lighted candle near to the surface of a tub in which beer is fermenting, the flame coming in contact with the gas will be instantly extinguished.

1112. *Not a supporter of combustion or life.*—Put a few grains of chalk in a tall glass, and pour upon it a tea-spoonful of hydrochloric acid, effervescence will take place, and gas be liberated. Although the glass is open at the top, yet as carbonic acid gas is heavier than atmospheric air, it will not escape, but occupy the glass and displace the common air previously contained. Immerse a lighted taper in the glass thus filled, when its flame will be instantly extinguished. If a mouse be held in the jar it will be suffocated.

1113. *Preserving insects, &c.*—The last experiment suggests a method of destroying insects for the cabinet, and is a much preferable mode of instantaneously killing them than many others frequently adopted.

1114. *Effects on larger animals, choke damp, Grotto of Dogs, &c.*—Several of the above experiments show that carbonic acid gas received into the stomach occasion no ill but rather beneficial effects. This is not the case when admitted to the lungs. Persons smelling the bungholes of casks of fermenting liquors have been known to fall dead from suffocation. It is also that deleterious gas called charcoal fumes, so many fatal instances of the breathing of which yearly occur. It is also the choke damp of the miner, and is often formed at the bottom of old dry wells, casks, &c. It may be known to exist in them by the extinction of a lighted candle. The Grotto of Dogs in Italy, has its name from the practice of putting dogs into it, who immediately fall down from suffocation. They are afterwards recovered by immersion in cold water, and answer the same purpose for the *gratification* of the next company of visitors. The carbonic acid gas in this cavern will not have the same effect upon man, because from its gravity it keeps its station at the bottom, reaching no higher than the knee; the rest being occupied by common air, consequently it will have that effect upon the respiration of a dog or other small animal that it cannot have upon a human being.

1115. *Carbonic acid gas evolved from the lungs in respiration.*—If a person breathes repeatedly into a phial, or other vessel containing pure lime-water, the clear liquid will become quite turbid. This is caused by the combination of the pure lime with the carbonic acid proceeding from the lungs during each expiration. The milky appearance is owing to the insolubility of the carbonate of lime. The expiration of carbonic acid gas from the lungs is owing to a decomposition which the atmospheric air undergoes, whilst acting on the blood. The blood returning by the veins from all parts of the body is loaded with carbonaceous matter, and is of a *purple* color. The oxygen of the common air combining with the carbon, forms carbonic acid, which flies off, and from its specific gravity descends towards the earth. The blood is changed to a *vermillion* color, and is ready for fresh emission by the contractile power of the heart. Meantime, the nitrogen of the common air inhaled is set free, and will be exhaled with the carbonic acid gas. The nitrogen gas, being lighter than either atmospheric air or carbonic acid gas, ascends; whilst the latter descends, thus making room for a fresh inspiration of atmospheric air, which enters between the two currents of the before-mentioned gases.

1116. *Density of the gas.*—Having a tall glass full of carbonic acid gas, as in *Ex.* 1112, and also a lighted candle standing beside it on the table, hold the open top of the glass downwards over the candle, in the same manner as if to pour water out of the glass, the gas will fall down upon and extinguish the candle.

1117. *Decomposition of carbonic acid gas.*—Place a piece of potassium in an iron spoon, and heat it until it inflames; now immerse it as quickly as possible into a jar of carbonic acid, the ignited potassium will decompose the gas, attract to itself the oxygen, forming potass, and liberate the carbon which will fall down as a fine black powder.

1118. Procure a strong glass tube, like that of *Ex.* 283,—put into one end of it a bit of phosphorus, and an equal quantity of chalk, then close the tube and apply heat, the phosphorus will decompose the carbonic acid that the heat drives from the chalk, absorbing its oxygen and becoming phosphoric acid; this at the same time unites with the lime, and forms phosphate of lime, while the other portion of the carbonic acid, namely, charcoal, is deposited.

1119. *Procured from earthy carbonates by heat. Lime burning.*—Inclose pieces of chalk, limestone, or marble in an earthen or iron retort, bring it to a red heat, and after the common air has been expelled, collect the produce, it will be found pure carbonic acid gas. This is the cause and the effect of the conversion of chalk into lime, that earth in a pure caustic state being found in the retort afterwards. See *Lime.*

1120. *Arises from and is absorbed by vegetables.*—Put a few fresh gathered cabbage leaves in a jar of carbonic acid gas, the jar being closed at the top, and standing in a saucer of water, and expose them to the direct rays of the sun. After three or four hours, upon trying with a lighted candle the quality of the gas still remaining, the carbonic acid will have been absorbed, and oxygen found instead of it in the jar. If the time of the experiment be night instead of day, and a jar of oxygen be used instead of carbonic acid gas, the reverse will take place, oxygen will be absorbed, and carbonic acid given out. This is in a philosophical point of view an important experiment, as it shows the effect of vegetation upon an atmosphere contaminated by the respiration of animals.

1121. *Acid properties of.*—Perform *Ex.* 1093 with this gas instead of carbonic oxyde, and the effect will be found very different. The litmus paper or infusion of cabbage being changed of a red color, showing that the gas is acid in its chemical character. It also combines with the alkalis and metals, forming carbonates.

Liquifying action of.—Carbonic acid gas when submitted to the pressure of 36 atmospheres becomes a liquid lighter than water and not miscible with it. The apparatus in which carbonic acid may be liquified is a bent tube 8 inches long and a ¼ of an inch in diameter, as in *Ex.* 283; but as great danger is to be apprehended by the employment of so fragile an article as glass, the following apparatus is preferable. It is nearly that of Mr. Smith, of the Adelaide Gallery, and is one generally employed by lecturers for this purpose.

A is an extremely strong cast-iron vessel, protected internally by a coating of lead. This contains fragments of carbonate of lime. B is an aperture by which they are introduced. C a force pump, by which hydrochloric acid is made to ascend through the fragments of carbonate of lime. D the receiver, in which the carbonic acid is collected. By appropriate stop cocks more carbonate of lime may be introduced, and the muriate of lime already formed withdrawn. The carbonic acid is liberated as the hydrochloric acid takes the lime, and gradually becomes liquid as it accumulates in the receiver.

1122. *Solidification of.*—When liquid carbonic acid is collected in the above apparatus, if the stop cock at the end of the receiver is turned on, the gas withinside will instantly return to a gaseous state, and issuing from the jet will be immediately frozen by the cold produced by its own evaporation, and will fall from the orifice of the jet in the most beautiful white and glittering flakes, like those of snow. This is one of the most interesting experiments that even chemistry affords.

1123. While carbonic acid gas is issuing from the jet of the stop cock in the apparatus, hold the bulb of a spirit thermometer in it; the temperature will sink immediately to 90° below zero.

1124. If a few drops of ether be previously inclosed in the receiver, its vapor will rise along with the gas, and increasing its conducting power, a still greater degree of cold will be produced, amounting to 194° Fahr., the greatest degree of cold yet produced or witnessed.

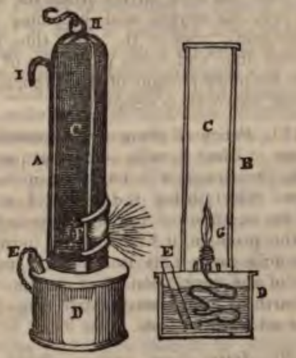
1125. *Light carburetted hydrogen, bihydroguret of carbon, fire damp of coal mines, inflammable air of marshes, heavy inflammable air.* (Car + H 2 = 8.)—"This gas" Brande says, "cannot be made by artificial means; it may however be readily obtained from marshes by stirring the mud at the bottom of stagnant pools, and collecting the gas which is disengaged in glass vessels inverted over it, and full of water, a large quantity being formed there by the decomposition of dead vegetable matter. It is almost always mixed with a small quantity of carbonic acid when obtained in this manner, and also when procured from a coal mine; by agitating it with lime water, or a solution of potass, the acid gas is removed."

1126. Blow some soap bubbles with a mixture of this gas and oxygen, apply a flame to them, when they will explode with a terrific report.

1127. Instead of oxygen use atmospheric air, the bubbles will also explode upon flame being applied, but with less force than in the former instance. 3 or 4 inches of the carburetted hydrogen are quite sufficient for either of the above experiments.

1128. It was to defend the miner from the destructive effects of the explosion of this gas, united with atmospheric air, that Sir H. Davy invented his safety lamp. As experiments with this are not easily performed with light carburetted hydrogen, on account of the difficulty of procuring the gas; olefiant gas, such as is burnt in the streets and supplied by gas companies, may be employed with the same result. The coal gas consists principally of olefiant gas and the light carburetted hydrogen. That mixture which is most dangerously explosive is 1 volumn of gas to 7 or 8 of air; when mixed in equal proportions, they burn but not explode, even 4 of air to 1 of gas will not explode. Light carburetted hydrogen does not explode under any circumstances except by the contact of flame, whereas olefiant gas is inflamed by a red hot wire, and also by red hot charcoal.

Davy's safety lamp.—The value of this ingenious instrument depends upon the principle just mentioned of the light carburetted hydrogen being explosive only when mixed with certain proportions of atmospheric air, but a medium state is found where the gas is inflammable, but not explosive. If a miner carrying an unshielded candle enter such an atmosphere, the flame of the candle would become enlarged, and of a more yellow color than before. This state of things informs him that he is on the margin of an explosive atmosphere, but, alas, he cannot escape; the gas around the candle burns, and communicates a flame instantaneously to adjoining portions—these to others more distant, and more highly charged, consequently a sudden explosion takes place, and destruction follows. The value of the safety lamp is to confine the flame within the instrument, and thus the miner, when on the verge of danger may retire, from a mixture of gas not merely explosive, but which are also incapable of supporting respiration. We will describe the safety lamp, and afterwards its action. The cut beneath shows at A its external appearance, and at B its internal structure.



C is a tube of wire gauze, closed at the top, and fitting at the bottom to a ring, which fits by a screw on to the lamp. Three wires marked H, with a hook I, inclose the wire gauze, and keep it from injury. F is a bull's eye lens, to concentrate the light of the flame within, which is shown at G. D is the reservoir for oil. E the supply pipe. The lamp being lighted, the air or gas burns within the lamp, and the reason why it does not communicate to the surrounding external atmosphere is the cooling property of the wire gauze. The heat of flame is that of a *white* heat, and if any diminution of temperature arises in it, it ceases to be flame. As before stated, light carburetted hydrogen is inflammable, not by the contact of a *red* hot substance, but by the contact of flame only. The reason then why flame is not communicated through the wire gauze is evident from the cooling property of the latter. We have also seen that the gas in its unmixed state is not a supporter of combustion; if then the miner proceed through a stratum where the gas is in too great abundance to be explosive, it extinguished his lamp, and in order that this may not subject him to inconvenience, he leaves this fatal atmosphere, and upon his emerging into a purer condition of the air, his lamp informs him of the fact by rekindling of its own accord. This it is enabled to do by a coil of platinum wire being attached to the wick of the lamp, as was explained in *Ex.* 527. The platinum continuing under these circumstances of a perfectly white heat.

Olefiant gas, hydroguret of carbon, bihydrocarbon. (Car 2 + H 2.)—This gas so well known as that which is burnt in our streets, and called according to its materials of production coal gas, oil gas, rosin gas, &c.—may be procured for ordinary purposes, by attaching a bladder to a common gas pipe, but as the gas thus prepared is mostly contaminated by light carburetted hydrogen, and by oily vapor, if the gas be desired perfectly pure, it must be procured as follows:—

1129. Mix together 1 part of alcohol, with 3 times its bulk of strong sulphuric acid, in a glass retort, and expose the mixture to a gentle heat. The retort should not be filled above one-third full, and when only a small quantity of the gas is required, $\frac{1}{2}$ an ounce of alcohol, with the proper quantity of sulphuric acid will be found quite sufficient. The alcohol and the acid must be shaken together before the heat is applied, a little ether is formed at first, and towards the end of the process, sulphurous acid, carbonic oxyde, and the bihydruret of carbon or light carburetted hydrogen are disengaged; the mixture also becomes quite black from the deposition of carbon, and is very apt to boil over. The pure olefiant gas is liberated only when the ether ceases to come over, this may be known by the odour of ether ceasing.

1130. *Gas from coals.*—The following cut shows the arrangement of the retorts when gas is manufactured from coals for the purposes of illumination. Fig. 1 showing a side section. Fig. 2 a front view. B is a furnace, supplied with coal. A the retort itself. This is of cast-iron, of an oval or semicircular cylindrical form. The front end of it is open for the reception of the coals to be distilled. When full of coals and ready for placing in the fire, the end is closed by a lid which fits tight, and is held firmly in its place by a bar across on the outside. A pipe C proceeds from the upper part of each retort, near the mouth, and these pipes, there being as many as there are retorts, all uniting with a main pipe D. The coals within the retorts being heated by the fire without, give off their gases, contaminated with various other products. The main pipe D conveys these to a well of water; in this the tar and other condensable products are retained. It is further purified by passing through a vessel filled with milk of lime, until it issues in a comparatively pure state into the gasometer, ready for use. The result of the distillation of coals are coke, gas, tar, and ammoniacal liquor. It is almost unnecessary to observe that it is this gas which is given off and burnt in candles, lamps, flame of fire, wood, &c.

1131. Mix together 3 parts of oxygen and 1 of coal gas. Blow soap bubbles with the mixture, and inflame them by a candle; they will detonate with a very loud report.

1132. Instead of oxygen, mix together 1 volumn of coal gas and 10 of atmospheric air; bring a candle near the mixed gases, explosion will take place. This shows the care requisite in entering any apartment, in which an escape of gas has taken place, with a lighted candle.

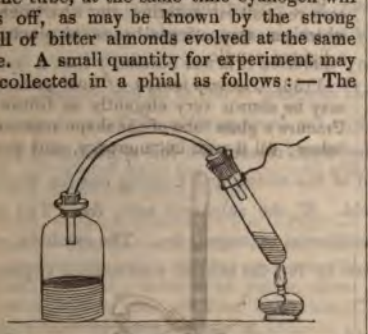
1133. *Decomposition of coal gas.*—This may be shown very elegantly as follows:—Procure a glass tube of the shape represented below; fill it with hot mercury, and pass up into it 2 grains of sulphur. Then attaching a retort charged as in *Ex.* 1125, pass up into it 1 inch of the gas, or if the retort be not

at hand, pass into it 1 inch of common coal gas, then taking the retort away, direct the heat reflected from a burning glass upon the sulphur. As this gets hot it will decompose the gas, its carbon will be deposited, and 2 inches of sulphuretted hydrogen will be found in the tube instead of 1 inch of the coal gas used, showing not merely the composition of the latter, but also the fact, that in olefiant gas the hydrogen is compressed into half its usual bulk.

1134. Mix together 1 volume of coal gas and 2 of chlorine; inflame them by a lighted candle, the result will be hydrochloric acid, with a deposition of charcoal. In this experiment the coal gas is decomposed, its carbon falls down while its hydrogen uniting with the chlorine forms the acid mentioned.

1135. If instead of inflaming the mixture of 1 volume of olefiant gas and 2 volumes of chlorine, the gases be merely mixed in equal volumes over water, or in a clean and dry glass globe exhausted of air, they act slowly upon each other, and a peculiar fluid is formed, which appears like a heavy oil; hence the term *olefiant* gas, applied to this hydrocarbon by the Dutch chemists. *Chloric ether* is the term applied to this fluid by Dr. Thompson, and *hydrochloride of carbon*, by Professor Brande.

1136. *Cyanogen, bicarburet of nitrogen, prussine.* ($\mathrm{Car}\ 2+\mathrm{N}=26$.)—A gaseous substance of peculiar character, and which united with hydrogen, forms the well-known prussic acid. It may be obtained as follows:—Place some dry pure crystals of the cyanuret of mercury in a test tube, heat the tube over a charcoal fire, holding it by a long wire until the crystals become black. The mercury will be evaporated, and if the tube be long, the distilled mercury will condense in the cold part of the tube, at the same time cyanogen will pass off, as may be known by the strong smell of bitter almonds evolved at the same time. A small quantity for experiment may be collected in a phial as follows:—The mercury will run down to the bottom, and the gas remain above the mercury in the phial; for being twice the weight of atmospheric air, it will sink and displace the air in the phial.



1137. Take a phial full of the gas, and suddenly immerse a lighted taper in it, the flame will be instantly extinguished, but at the same time the gas takes fire and burns with a very peculiar and beautiful purple flame, different in appearance from that of any other gas.

1138. Suffer the gas as issuing from the bent tube attached to the test tube of *Ex.* 1136, to be received beneath the surface of spirits of wine. This fluid will absorb twenty-three times its volume of the gas, will acquire its peculiar odour, and upon light being applied will burn of a fine purple color.

1139. *Liquefaction of.*—Condense the gas in a bent tube as in *Ex.* 283; at a very slight pressure, not more indeed than between 3 or 4 atmospheres, the gas will become liquid. It is in this state limpid and colorless like water.

1140. Fill a bladder with cyanogen, and fasten to it a condensing syringe, the other end of the syringe having a small and strong glass closed tube. Inject the gas from the bladder into the tube by means of the syringe. In a very short time, the pressure will be sufficient to liquefy the gas. This is an experiment attended by little or no danger, on account of the little explosive force which the liquid gas possesses. If the tube be opened or broken, the expansion is inconsiderable, but the cold produced very great, as may be witnessed by allowing it to issue on the bulb of a spirit thermometer.

1141. Mix together 1 volume of cyanogen and 2 of oxygen, apply flame to the compound. It will detonate with violence, and be resolved into two volumes of carbonic acid and one of nitrogen.

1142. *Fluoboric gas, fluoboric acid.* ($\mathrm{Fl}+\mathrm{B}=128$.)—Mix in a retort equal parts of fluor spar and vitrified boracic acid. Upon the application of heat to the retort, this gas will be liberated. It must be received over mercury, as water absorbs 400 times its own bulk, thereby forming a caustic solution of *borohydrofluoric* acid.

1143. *Rapid absorption by water.*—Suffer some bubbles of the gas to escape into the air, they are immediately converted into white fumes, from the rapid absorption of the moisture of the atmosphere.

1144. Dip into a jar of this gas a piece of writing paper, it will soon become of a perfectly black color, and crumble away into a powder, which upon examination will be found pure charcoal. The gas rapidly absorbs the oxygen and hydrogen from the paper, and leaves its third element, the carbon.

1145. A small lump of sugar let fall into the gas will in like manner become changed into charcoal. In these and like experiments the gas is rapidly absorbed, as may be seen by the rising of the mercury in the tube or jar holding the gas.

1146. Perform the same experiment with a small piece of meat, it will be rapidly eaten away. The gas accidentally received in the nostrils produces a highly irritating effect, occasioning a smarting pain; if inhaled into the lungs, the most violent coughing succeeds.

1147. Receive some bubbles of the gas in a test tube partly filled with water stained blue by litmus. The blue color will be changed to a red, showing the acid character of the gas. As in this experiment the element of water may be thought to affect the result, it may be tried by holding a piece of dry litmus paper before the mouth of a retort from which the gas is issuing; it will be changed red as when water is present.

TERNARY COMPOUNDS

Are those in which three elements are contained; they include a great class of chemical bodies,—among which are most vegetable products, gum, sugar, wood, resin, and others. Also the majority of the vegetable acids are no less compounds of three elements—oxygen, hydrogen, and carbon. Various classes of salts, using this term in both its limited sense of being a combination of an acid with some base, or in its more general one of a mere union of elements presenting a salt-like form, are likewise among the ternary compounds. Of the latter kind are some of the ammoniurets or combinations of ammonia, and the cyanurets or compounds of cyanogen. Of the former are the salts formed with the binary acids heretofore described; the sulphates, the nitrates, &c. This will be rendered plain by considering the composition of any one of them; for example, the nitrate of silver. This salt as before observed, (p. 86,) is composed of two binary compounds;—oxyde of silver is one, nitric acid the other. But it will be observed that oxygen occurs in each, the symbol of the first is $Ag.\ O$, of the other, $N+O\,5$; and the whole combination of the nitrate of silver is $Ag+N+O\,6$, or of three elements. The above symbol of $Ag+N+O\,6$, would enable us to ascertain the atomic weight of this salt to be 170. Still it would be very inadequate to show the constitution of the salt; we are therefore obliged to keep the element oxygen distinct in each binary, and writing the symbol in full to put $Ag.\ O+N.\ O\,5$. Moreover it is understood by chemists, that a metal combining with an acid always does so in the state of an oxyde; therefore it is not necessary that a symbol representing such a salt should show the oxyde character of one of its components, besides which the metal most often becomes oxydized by the decomposition of that acid, or by the decomposition of water in union with it. For these reasons the full symbol need not be given, but is *simplified* by using the symbol of the metal, and forming one for the acid. Thus N' is made to designate the nitric acid. S' the sulphuric acid, &c. The same would hold good with ammonia and the ammoniurets, cyanogen, &c. The symbols, given in the third column of page 86, may therefore be for the sake of convenience expunged, and the following conveniently substituted:—

Ammonia	Am	Sulphuric acid	S'	Carbonic acid	C'
Lime	Cal	Sulphurous acid	S''	Acetic acid	A'
Alumina	Al	Nitrous acid	N''	Water	W
Potass	Pot	Nitric acid	N'	Hydrochloric acid	M'

CHLORATES OR TRIPLE COMPOUNDS OF CHLORINE.

1148. *Chlorate of ammonia.* See *Ex.*775.—Pour into a tube, about 2 feet long and ½ an inch in diameter, a strong solution of chlorine in water to within 2 inches of the top, then gradually pour upon it liquid ammonia so as to fill the tube, which is to be closed by the thumb and inverted into water; the solution of ammonia then rises through that of chlorine, and is decomposed with effervescence; nitrogen being evolved, and the hydrochlorate of ammonia retained in solution.

1149. *Hydrochlorate of ammonia, sal ammoniac, muriate of ammonia.* $(\mathrm{Am} + \mathrm{M}'.)$—This salt is found native in Italy and other places; it is now however chiefly a manufactured article, made by adding common salt to a sulphate of ammonia. Three decompositions take place, common salt is the chloride of calcium; the sulphuric acid leaves the ammonia, and unites with the sodium converted into an oxyde by the decomposition of water, the oxygen of which it abstracts; the hydrogen set free adheres to the chlorine, and forms hydrochloric acid; this then dissolves the ammonia left by the sulphuric acid, and forms with it the hydrochlorate of ammonia. In the former experiment the union of chlorine and ammonia was effected by a partial decomposition of the latter, but in this the ammonia is not decomposed.

1150. *Second method.*—Mix together equal volumes of ammonia and hydrochloric acid, when an entire condensation ensues, and phenomena before adverted to in *Ex.* 16. Considerable heat will be produced during the combination of the gases.

1151. Pound in a mortar 1 ounce of sal-ammoniac; adding then 3 times its weight of water, a great degree of cold will be produced. If the solution be made in a phial, and the phial be held in the hand, the cold will be very sensibly felt.

1152.—Dust the hand over with powdered sal ammoniac, and then dip it into water, or else place a tea spoonful of the powdered salt in the hollow of the hand, and pour a table spoonful of water upon it, the cold will be very severe and disagreeable.

1153. *Chlorate of potass.* $(\mathrm{Pot.} + \mathrm{Chl}'.)$—To make this interesting salt for the sake of experiment only, chlorine gas may be passed through a solution of potass, afterwards evaporate the solution, when small white glistening tabular scales of chlorate of potass will be deposited upon the liquor getting cold. It is convenient to use a series of Woolf's bottles for this experiment, see *Chlorine.* The carbonate of potass may be used with equal success. In this case, carbonic acid will fly off, occasioning an effervescence in the liquor.

1154. Pound the chlorate of potass in a mortar in the dark, or rub it on a board with the face of a hammer; it will appear at such times phosphorescent.

The extraordinary properties which this salt possesses, inflaming or detonating by contact or friction with other bodies, are given in *Ex.* 15, 45, 46, 47, 48.

1155. *Congreve lucifers.*—These are the lucifers in common use, and may be known from those described under the subject phosphorus by the crackling noise made when they are ignited. Berzelius gives the following as the best composition for the matches:—30 parts of powdered chlorate of potass, 10 of powdered sulphur, 8 of sugar, 5 of gum arabic, and a little cinnabar as a color to the whole. The sugar, gum, and salt, are first rubbed together into a paste, with a sufficiency of water; the sulphur is then added, and the whole being thoroughly beaten together, small brimstone matches are dipped in, so as to retain a thin coat of the mixture upon their sulphured points; they should be quite dry before they are used, and may be inflamed either by friction or contact with sulphuric acid. When the latter is preferred, a few drops of the acid are inclosed in a small phial along with some shreds of asbestos. Aspin and poplar are considered the best woods for matches.

1156. *Priming for percussion caps.*—"One of the compounds used for this purpose depends for its quality upon the chlorate of potass. 10 parts of gunpowder are rubbed with water, and the soluble part poured off; the remaining paste is then mixed with 5½ parts of the chlorate of potass, and a drop of it put into each of the small copper caps adapted to the peculiar nipple of the touch-hole of the gun; a blow being struck upon the cap, the powder is inflamed, and communicates to that in the barrel. The great disadvantage of this compound is, that it forms products which soon rust the touch-hole and surrounding parts, fulminating mercury is therefore now generally substituted."—*Brande.* This powder must not be handled when dry, as it is very apt to explode with the slightest friction.

1157. Put into a tall glass of water some shreds of phosphorus, let fall upon them a little chlorate of potass, then immediately and before the chlorate can dissolve, introduce by means of a long dropping tube, or a syringe like that of *Ex.* 888, but straight in form, a drop or two of sulphuric acid, taking care that the acid shall touch the salt; a beautiful effect will take place, the phosphorus presently inflames in various parts of the fluid, and burns vividly, forming a kind of well of fire.

To make oxygen from chlorate of potass. See *Ex.* 209 and 210.

To procure chlorous acid from ditto. See *Ex.* 775.

1158. *To make an extemporaneous bleaching liquid.*—Put a few grains of the chlorate of potass into a tea spoonful of hydrochloric acid, then dilute it with water; this is a very simple and useful bleacher for substances soaked in it for a short time.

1159. *Oxychlorate or perchlorate of potass.*—Moisten 1 part of chlorate of potass with 3 of sulphuric acid, and subsequently warm the mass until it becomes white, and the peroxyde of chlorine is expelled. In this state it consists of bisulphate and oxychlorate of potass. Now add cold water which will wash away the bisulphate and leave the oxychlorate. Most of the experiments given of the last substance may be performed with this and with the same result.

1160. *Chlorate of soda.* ($\mathrm{S} \times \mathrm{Chl}'$)—Procured by the same process as chlorate of potass—also by adding soda to chloric acid. When in solution it is difficult to separate it from the chloride of soda, which is formed at the same time. If desired pure, the solution of both must be evaporated, and the crystals treated with alcohol, this will first dissolve the chlorate. When it has done so, the alcohol is poured off, and being evaporated, the chlorate is obtained in flat scaly crystals, similar in appearance and general properties to those of the chlorate of potass. It is seldom used.

1161. *Chlorate of lime.* ($\mathrm{Chl}' + \mathrm{Chl}'$)—Dissolve chalk in chloric acid. This salt is very soluble and deliquescent. Exposed to heat it changes to the chloride, oxygen being evolved.

1162. *Chlorate of baryta.* ($\mathrm{B} + \mathrm{Chl}'$)—Pass chlorine through a solution of baryta water. The chloride and chlorate are formed at the same time. The separation of these similarly soluble salts is the only difficulty. Brande gives the following receipt:—"Add to a solution of the mixed salts, a solution of phosphate of silver in acetic acid, by which the chloride of barium is decomposed, and resolved into chloride of silver, and phosphate of baryta, both of which are insoluble. The chlorate therefore alone remains suspended in the solution."

1163. Sprinkle the crystals of chlorate of baryta with sulphuric acid; they will become luminous, and are decomposed into the sulphate of baryta and chloric acid. See *Chloric Acid, Ex.* 777.

1164. *Chlorate of strontia.* ($\mathrm{Str} + \mathrm{Chl}'$)—is obtained in the same way as the chlorate of baryta. Thrown on red hot coals it burns with a beautiful purple light. As the chloride is formed at the same time, it must be purified from the latter, in the same manner as the chlorate of soda, by means of alcohol, which dissolves the chloride but not the chlorate.

1165. *Chlorate of magnesia.* ($\mathrm{Mag} + \mathrm{Chl}'$)—"Mix a solution of fluosilicate of magnesia with a hot saturated solution of chlorate of potass as long as a precipitate falls."—*Berzelius.*

1166. *Chlorates of silver, mercury, lead, copper, and zinc,* are formed by digesting the oxydes of these metals, or the carbonates, in chloric acid. Of mercury there are two salts, the protochlorate and the perchlorate, according as the protoxyde or peroxyde are used.

Those metals, whose oxydes are acid, such as arsenic, chromium, and others, do not of course form a salt by admixture with chloric acid; and although chlorates of manganese, iron, antimony, bismuth, &c., may be formed in the manner of the chlorate of magnesia, yet being of no practical utility little is known of them.

1167. Soak pieces of paper in solutions of the various chlorates, and dry them afterwards by exposure to the air, or a very gentle artificial heat. Afterwards set fire to the paper; it will burn with more or less rapidity, giving out a different-colored light, according to the chlorate used. Thus that dipped in the chlorate of potass will be white and sparkling; that in barytes, purple—in strontian, red. But the most beautiful is that dipped in the chlorate of copper, which burns of a fine green. All the chlorates when heated give out oxygen, and are converted into chlorides.

IODATES.

1168. *Iodates of potass and soda.* ($\mathrm{Pot} + \mathrm{I}'$)—Upon any quantity of iodine pour a solution of potass, till the liquor ceases to be colored. Evaporate to dryness, and digest the dry salt, which consists of hydriodate of potass and iodate of potass, in strong alcohol. As the iodate is not soluble in this liquid, and the hydriodate is, the two salts easily separate from each other. After having washed the iodate two or three times with alcohol, dissolve it in water, and neutralize it with acetic acid. Evaporate to dryness, and digest the salt in alcohol to remove the acetate. After two or three washings the iodate is pure. The iodate of soda may be procured by a similar process.

1169. Throw a few grains of the iodate of potass upon hot coals; it will burn with a beautifully blue or rather purple flame.

1170. *Explodes with charcoal by percussion.*—If 6 grains of charcoal, in powder, be gently mixed with 6 grains of iodate of potass, and laid, (folded in a small piece of paper,) on an anvil, a smart blow from a hammer will cause a loud detonation.

1171. *Explodes with red-hot charcoal.*—Throw a few crystals of iodate of potass on red-hot charcoal; a very beautiful deflagration will be the consequence. Here the iodate is decomposed; the charcoal combines with the oxygen of the potass, forming carbonic acid, some of which unites with the potass.

1172. *Deflagrates with inflamed phosphorus.*—Put a piece of phosphorus into a crucible; when it begins to burn throw in a few grains of iodate of potass—a very violent deflagration will be the consequence.

Deflagrates by percussion with. See *Ex.* 50.

1173. *Iodate of baryta.* $(\mathrm{B}+\mathrm{I}')$—Add iodine to baryta water; they will combine, and the iodate of baryta fall down as a white powder. When strongly heated, it is resolved into oxygen, iodine, and baryta, showing its composition to be of these three elements, and that it is not an iodide of barium. It is almost insoluble in water.

1174. *Iodate of strontian.* $(\mathrm{Str}+\mathrm{I}')$—Add iodine to strontian water, and agitate them together. It is a white powder, soluble in four times its weight of cold water.

1175. *Protiodate of iron.* $(\mathrm{Protfer}+\mathrm{I}')$—Make a solution of the protosulphate of iron, and add to it the iodate of potass; the result is a *yellow* precipitate of the protiodate of iron.

1176. *Periodate of iron.* $(\mathrm{Perfer}+\mathrm{I}')$—Instead of the protosulphate use the persulphate of iron; the precipitate will be white. It is the periodate.

1177. *Iodate of zinc.* $(\mathrm{Z}+\mathrm{I}')$—Add a solution of iodate of potass to a solution of sulphate of zinc. The iodate thus formed is white, and soluble with difficulty in water.

1178. *Iodates of copper, lead, and bismuth,* are made in the same manner.

1179. *Iodates of mercury.*—The iodate of mercury, made by adding the iodate of potass to a solution of the protonitrate of mercury, is white and insoluble; that formed with the pernitrate is soluble—the solution will therefore contain the periodate of mercury and the nitrate of potass.

1180. *Iodate of silver.* $(\mathrm{Arg}+\mathrm{I}')$—Add oxyde of silver to the iodic acid, or else add the chlorate of potass to the nitrate of silver. It is a white powder, very soluble in ammonia.

BROMATES.

1181. *Bromate of potass and soda.* $(\mathrm{Pot}+\mathrm{B}')$—Mix together bromine and a solution of potass; the bromate will fall down as a white crystalline powder, while the bromide of potassium remains in solution, both being soluble in water they will both remain suspended unless the potass be in excess—the precipitation taking place only in supersaturated solutions, and then merely in consequence of the greater solubility of the one suffering the other to fall. The bromate of soda may be formed in like manner. The only other bromates are those of baryta, lime, lead, mercury, and silver. They are of little use; if required they may also be made by the above method.

HYPONITRITES.

1182. *Hyponitrite of potass.*—Put the nitrate of potass into a crucible or iron bottle, as when oxygen is made from saltpetre. See *Ex.* 206. Submit it to heat, and watch the time when other gases arise along with the oxygen which first passes over, the salt left in the bottle will be hyponitrite of potass. A better method is the following:—

1183. Add a solution of hyponitrite of lead obtained by the next experiment to a solution of the sulphate of potass; a sulphate of lead is thrown down as an insoluble salt, and a hyponitrite of potass left in solution. To obtain it in crystals filter the solution, and evaporate the filtered liquor to dryness.

1184. *Hyponitrite of lead.*—Boil lead for an hour in a solution of nitrate of lead, the nitric acid will be partially decomposed, a portion of its oxygen uniting to the metallic lead, and the salt becoming the hyponitrite.

1185. *Hyponitrite of silver* may be obtained in like manner.

NITRATES AND NITRITES.

The nitrates are of the highest importance in the arts and manufactures, and may be readily obtained, in most cases, by adding the nitric acid to the various bases. They are all soluble in water, and therefore cannot be precipitated by any admixture of other matters, although the base may often be so.

1186. *Nitrate of potass, saltpetre, nitre.* $(\mathrm{Pot}+\mathrm{N}'.)$—This valuable salt occurs native in many places. It is yet frequently manufactured from putrid animal and vegetable matter, the decomposition of which occasions the spontaneous formation of nitre. Dry ditches are dug and covered with sheds open at the sides, at the same time to keep off the rain and admit the wind. These are filled with dung, the remains of vegetables, and old mortar, or other loose calcareous earth. A certain portion of nitrate will soon be formed, after which the process proceeds more rapidly until so much is produced as to check the further action, this being dissolved away by water, enables the remains of animal and vegetable matter to be decomposed still more. After a succession of many months, more or less, according to the management of the operation, in which the action of a regular current of fresh air is requisite, nitre is found in the mass. If the beds contained much vegetable matter, a considerable portion of the nitrous salt will be common saltpetre; but if otherwise, the acid will be for the most part combined with the calcareous earth. The nitre thus obtained being a mixture of the nitrates of lime and potass and common salt, is first placed in tubs along with woodashes or potass, this decomposes the nitrate of lime, which is retained in the tubs when the soluble salts are drawn off. It is then boiled and concentrated, whereby most of the common salt is deposited, the solution of potass floating above the precipitate of salt is poured off and set aside to crystallize; as a hot solution of common salt does not deposit crystals on cooling, but saltpetre does, therefore this is readily obtained. It may for nice purposes be purified a second and even a third time. A pint of water dissolves a pound of nitre.

1187. For the sake of experiment, if a sample of pure nitrate of potass be required, it may be made by adding nitric acid to the carbonate of potass.

1188. *Sal prunella, crystal mineral.*—This is nothing more than common saltpetre fused in an iron ladle, and poured into a bullet mould; it consequently congeals in round balls, and as such is sold as a simple cooling medicine, that is when taken in small quantities, otherwise it is poisonous. If this salt be suffered to remain for some time melted, it becomes converted into the *nitrite* of potass, and if the heat be urged so that the salt becomes red hot, oxygen is evolved, and as before stated becomes the *hyponitrite.*

1189. *Produces cold when dissolved.*—The cold produced by saltpetre mixed with water is very great, so that if a crystal be put into the mouth, and there left to dissolve, it will occasion so great a sensation of cold, that the peculiar taste of it will not readily be distinguished. If 1 part of powdered nitre be mixed with 5 of water, the thermometer which stood at 60° in the water will sink to 45 or even lower in the mixture.

1190. *Decomposition by heat.*—Throw a few crystals of saltpetre in the fire, they will be decomposed with rapidity, occasioning a strong ignition not accompanied with flame, and which is much increased by union with other combustibles; hence the value of saltpetre in gunpowder, fire-works, and other pyrotechnic exhibitions. The following receipts will show its nature in various of these mixtures.

RECEIPTS, ETC., FOR FIRE-WORKS.

1191. *To make touch paper.*—Dip a piece of any unsized paper, such as blotting paper, blue paper, or printing paper, in a solution of an ounce of saltpetre in nearly ½ a pint of water; then letting it get perfectly dry it will be fit for use. The burning of this paper will show the nature of the combustion of this salt, for the paper will not inflame, but burn rapidly away, with a red flameless combustion.

1192. *To make slow match.*—A slow match is used to fire ordnance and some fire-works, and more especially to keep a light in circumstance where other lights would be inconvenient or dangerous. A very loosely twisted rope is soaked in saltpetre water; when perfectly dry it is dipped in lime white. The use of the saltpetre is to ensure the ropes continuing to burn, and that of the lime is to prevent too quick an ignition.

1193. *To make fusees.*—Take 8 or 10 or more strands of lamp cotton, boil them in vinegar or spirits of wine, and draw them through gunpowder made into a soft paste with spirits of wine. Let them dry before using. Vinegar may be used instead of the spirits of wine. The only object of the liquid is to make the gunpowder adhere to the cotton, and water will not do well for the purpose, because it dissolves the saltpetre, and thus separates it from the other ingredients.

1194. *To make quick match.*—Make a fusee according to the last experiment, and draw it through a very narrow tube of paper, made by rolling paper on a wire, and fastening the edge with paste. Thus inclosed, the saltpetred cotton burns with very great rapidity, whereas without such inclosing tube, it burns slowly, more especially when lime is added to the powder.

Compositions for filling rockets.—It is an axiom among fire-work makers, that the smaller the case, so much *quicker* must be the composition to fill it, or in other words, the mixture that will do for a small case will burn too rapidly when placed in one of larger cavity. Hence it follows, that the same composition will not do for large and also for small rockets. The following are some of the most approved receipts:—

1195. *For rockets of* 1 *or* 2 *pounds.*—Mealpowder 2 pounds, saltpetre 8 ounces, brimstone 4 ounces, charcoal 2 ounces, steel-filings 1 ounce and a half.

1196. *For rockets of from* 1 *pound to* 4 *ounces.*—Mealpowder 1 pound, saltpetre 4 ounces, brimstone 3 ounces, charcoal 1 ounce and a half.

1197. *For rockets under* 4 *ounces.*—Mealpowder 1 pound 4 ounces, saltpetre 4 ounces, charcoal 2 ounces.

1198. *Rocket stars. Common.*—Nitre 1 pound, sulphur 4½ ounces, antimony 4 ounces, isinglass ½ an ounce, camphor ½ an ounce, spirits of wine ¾ ounces.

1199. *White.*—Mealpowder 4 ounces, saltpetre 12 ounces, sulphur 6½ ounces, camphor 5 ounces. Or else, mealpowder 4 ounces, nitre 16 ounces, sulphur 7 ounces; or mealpowder 3 ounces, nitre 16, sulphur 8 ounces.

1200. *Blue.*—Mealpowder 8 ounces, nitre 4 ounces, sulphur 2½ ounces.

1201. *Amber.*—Nitre 8 ounces, sulphur 2 ounces, yellow amber 1 ounce, sulphuret of antimony 1 ounce, and mealpowder 3 ounces.

1202. *Crimson.*—Sulphur 1 ounce, sulphuret of antimony 1 ounce, chlorate of potass 1 ounce, nitrate of strontian 5 ounces,

1203. *Green.*—Chlorate of potass 5 parts, sulphuret of antimony 4 parts, sulphur 13 parts, nitrate of barytes 80 parts.

1204. *Purple.*—Lamp black 1 part, realgar or red arsenic 1 part, nitre 1 part, sulphur 2 parts, nitrate of strontian 16 parts, chlorate of potass 5 parts.

1205. *Tailed.*—Nitre 4 parts, sulphur 6 parts, sulphuret of antimony 2 parts, rosin 4 parts.

1206. *Tailed, with sparks.*—Mealpowder 1 ounce, nitre 1 ounce, camphor 2 ounces.

To make the stars it is requisite to mix and incorporate the compositions well together; those containing the chlorate of potass with the hand only, (because if ground such may explode;) and form the composition into a paste with spirits of wine, brandy, or vinegar, so that it shall resemble dough in stiffness; then cut it into pieces about the size of small marbles, roll them round in the hand, dust them over with mealpowder, and set them aside to dry.

1207. *Fiery rains* are often used instead of stars, and with a fine effect. They are made by substituting small cases like squibs for the stars.

1208. *Gold rain.*—Sawdust, 1 ounce, sulphur 2 oz., mealpowder 2 oz., glass dust 3 oz., nitre 8 oz. Or, mealpowder 4 ounces, nitre 16 oz., sulphur 4 oz., brass dust 1 oz., sawdust 2¼ oz., glass dust 6 drachms. Or, mealpowder 6 oz., nitre 1 oz., charcoal, 2 oz.

1209. *Silver rain.*—Mealpowder 2 oz., nitre 4 oz., sulphur 2 oz., sulphuret of antimony 2 oz., sal-prunella ½ an oz. Or, nitre ½ an oz., sulphur 2 oz., charcoal 4 oz.

1210. *Chinese fire.*—Mealpowder 1 ℔., sulphur 2 oz., sulphuret of iron 2 oz. (Made by throwing iron filings into melted sulphur, stirring them about, and when cold powdering and sifting them.)

1211. *Ancient fire.*—Mealpowder 1 ℔., charcoal 2 oz.

1212. *Brilliant.*—Mealpowder 1 ℔., sulphuret of iron 4 oz.

1213. *Red shower.*—Take deal sawdust, and boil it in water in which saltpetre has been dissolved. Take it out, and when dry spread it out on a table, and sprinkle it with equal parts of mealpowder and sulphur.

1214. *Composition for port fires.*—nitre 4 parts, mealpowder 1, and sulphur 2 parts. Or else nitre 3 parts, mealpowder 3, and sulphur 1 part.

1215. *Composition for Catherine wheels or pin wheels.*—Nitre 2 ounces, meal-powder 8, and sulphur 1 ounce.

1216. *Composition for serpents or squibs.*—Mealpowder 1 ℔., nitre 1¾ oz., charcoal 1 oz., steel filings 1 oz.

1217. *Composition for tourbillions.*—The same as that for rockets, in proportion to the size of the case.

1218. *Composition for gerbes.*—Mealpowder 1½ oz., iron sand, 5 oz.

1219. *Composition for Roman candles.*—Saltpetre 2½ ℔., mealpowder glass dust, and sulphur, each ½ a ℔.

1220. *Composition for spur fire for flower pots.*—Nitre 4½ ℔., sulphur 2 ℔., and lamp black, 1½ ℔. This is not only the most beautiful of all pyrotechnic compositions, but the most difficult to make, so much depends upon the quality of the ingredients and the manner of their combination. The following remarks may be useful:—Sift the saltpetre and sulphur together first; then put them into a marble mortar and the lamp black with them, which must be worked down by degrees with a wooden pestle, till all the ingredients appear of one color, which will be of a greyish black. When this is done drive a little into a case for trial, and fire it in a dark place; if sparks come out in the forms of stars, or the rowel of a spur, and in clusters, spreading well without any other sparks, it may be considered good; if it appear drossy, and the stars not full, it is not mixed enough; but if the stars are very small and soon break, it is indicative of an excess of rubbing. It is very singular that the fire thrown out by this composition, although very brilliant communicates no heat, so that if the hand be held in it, it will not be burned or injured.

1221. *Blue signal lights, Bengal lights.*—Mix 28 ounces of nitre with 12 of sulphur, and 2½ of realgar or orpiment; touched with a red hot wire, it burns with a vivid white light.

Deflagration with charcoal. See *Ex.* 363 and 364.

1222. *Deflagration with phosphorus.*—Throw some shreds of phosphorus upon red hot nitre, instant inflammation will ensue, and a phosphate of potass be formed, while a large quantity of nitrogen escapes.

1223. *Deflagration with sulphur.*—Throw sulphur upon red hot nitre, combustion of the sulphur takes place, nitrogen escapes, and a mixture of sulphate and sulphite of potassa remains.

1224. Into a ladle or crucible containing red hot nitrate of potass, throw a few filings of any of the following metals; detonation attended with other phenomena, will take place, according whether the metal be arsenic, antimony, bismuth, zinc, iron, lead, tin, copper, &c. The same often takes place with metallic sulphurets. See *Sulphuret of Arsenic. Ex.* 1225 and 1026.

1225. *To make fulminating powder.*—Mix together 3 parts of nitre, 2 of dry subcarbonate of potass, and 1 of sulphur. Put a few grains of this powder upon a fire shovel, which then place over the fire, so that the powder shall heat very gradually. It will in a minute or so turn black, fuse, emit a faint blue flame, and then explode with a tremendous report. Sometimes the violence is so great that the shovel is indented by the explosion.

1226. *Second receipt.*—Reduce separately to fine powder 4 ounces of nitrate of potass, 2 ounces of the sulphuret of antimony, and 1 ounce of sulphur, mix them well on a sheet of paper, with a wooden or ivory spatula, and preserve the compound in a dry phial. When it is to be used, lay about a dram or more on a piece of wood or iron, and fire it with a red hot iron wire; instant deflagration, accompanied by dazzling light and great heat, will take place.

1227. *Third receipt.*—Pulverize 4 drams of nitrate of potass and the same quantity of sulphuret of antimony; combine them, and throw about a dram of the mixture into a red hot crucible, immediate deflagration will be the consequence. If we continue to deflagrate the compound until the whole is exhausted, some of the revived metal (antimony) will be found at the bottom of the crucible. If the nitrate of potass be first melted, and the sulphuret then thrown in, the deflagration will be the same.

1228. *Deflagrates with plumbago.*—Into a crucible containing a little melted nitrate of potass, throw some powdered plumbago, deflagration will be the consequence. This experiment may be varied by mixing the two substances in powder, and throwing them into a hot crucible. The carbon will fly off in the state of carbonic acid, and oxide of iron will remain.

1229. *Deflagrates by percussion.*—A mixture of 10 grains of powdered nitrate of potass with 2 grains of phosphorus, will produce a very violent explosion when struck on an anvil by a hot hammer. Nitrogen gas, phosphoric acid, and phosphate of potass, are the results of this decomposition. The same phenomena take place when phosphorus is combined with nitrate of soda, and struck in the same way.

1230. *To make gunpowder.*—Pulverize separately 5 drams of nitrate of potass, 1 dram of sulphur, and 1 dram of newly-burnt charcoal: mix them together in a mortar with a little water, so as to make the compound into a dough, which roll out into round pieces of the thickness of a pin upon a slab; this must be done by moving a board backwards and forwards until the dough is of a proper size. When three or four of these strings or pieces are ready, put them together, and with a knife cut the whole off in small grains. Place these grains on a sheet of paper in a warm place, they will soon dry. During granulation, the dough must be prevented from sticking, by using a little of the dry compound powder. This mode of granulation, though tedious, is the only one to be used for so small a quantity, for the sake of experiment; in the large way, gunpowder is granulated by passing the composition through sieves.

1231. The following are English receipts for various gunpowders:—

	Nitre	Sul:	Char.
Common powder.......	75	12½	12½
Shooting powder.......	78	10	12
Miner's powder........	65	20	15

The larger the proportion of sulphur the less forceable will be the explosion of the powder; but it keeps drier than that in which the sulphur is in less proportionate quantity. *Mealpowder* is gunpowder not granulated, but in the state of a fine dust.

1232. *To try the quality of gunpowder.*—Place about a thimble full on a piece of white paper, and at 3 or 4 inches distance a similar heap, taking care that there shall be no loose grains between the two heaps; fire one of these by a red hot wire. If the flame ascend quickly with a good report, sending up a ring of white smoke, leaving the paper free from white specks and not burnt into holes, and if no sparks fly off from it so as to set fire to the contiguous heap, the powder is very good; if otherwise the ingredients are impure or badly mixed.

1233. Mix gunpowder with $\frac{1}{8}$ its weight of powdered glass, or other substance harder than itself, place a little of this mixture on an anvil, and strike it a heavy blow with a large hammer. It will most usually explode with a loud report.

1234. *Powder of fusion.*—3 parts of nitre, 1 of sulphur, and 1 of fine sawdust, well mixed, constitute what is called the powder of fusion. If a bit of copper be placed in a walnut shell, and surrounded with this powder, and the powder afterwards set fire to with a lighted piece of paper, it will detonate rapidly, and fuse the metal into a globule of sulphuret, without burning the shell.

1235. *Nitrate of soda, cubic nitre, quadrangular nitre.* $(\mathrm{Sod} + \mathrm{N}'.)$—Add nitric acid to the carbonate of soda.

1236. Add soda to any of the metallic nitrates, except that of barytes.

1237. Distil common salt with 3 times its weight of nitric acid.

1238. *Utility of.*—This salt has been considered as useless, but Professor Proust says, "that 5 parts of it, with 1 of charcoal, and 1 of sulphur, will burn three times as long as common powder, so as to form an economical composition for fireworks. It however gets damp by exposure to the air, which the compositions of saltpetre do not, if the salt be pure."

1239. *Nitrate of lime.* $(\mathrm{Cal} + \mathrm{N}'.)$—The calcareous nitre of old authors abounds in the mortar of old buildings, and may also be made, not merely by adding nitric acid to chalk, but is formed during the artificial production of saltpetre. (See *Nitrate of Potass.*) It deliquescences on exposure to the air, and is soluble in one-fourth its weight of water. Its crystallization is very beautiful, resembling long needles diverging from a centre. No use is made of this salt.

1240. *Nitrite of lime.* $(\mathrm{Cal} + \mathrm{N}''.)$ *Baldwin's phosphorus.*—Melt in a crucible or ladle some of the nitrate of lime, keep it in a state of fusion for ten minutes, then pour it into an iron pot previously heated. This is Baldwin's phosphorus, and may be considered the nitrite of lime.

1241. Baldwin's phosphorus broken into pieces, and kept in a phial closely stopped, will emit a beautiful white light in the dark, after having been exposed some time to the rays of the sun.

1242. *Nitrate of baryta.* $(\mathrm{Bar} + \mathrm{N}'.)$—Dissolve the native carbonate of baryta in nitric acid, and evaporate to dryness. It forms eight-sided crystals, soluble in 12 parts of cold and 4 of boiling water. It is used as a test to detect sulphuric acid when nitric acid is contaminated with it: but for such purpose a very weak solution must be used. The acid to be tested must also be diluted.

1243. *Nitrate of strontian* $(\mathrm{Str} + \mathrm{N}'.)$ may be obtained in the same manner as that of baryta, with which it agrees in the shape of its crystals, and most of its properties. It is much more soluble however; requiring for its solution, but 4 or 5 parts of cold water, and about half as much hot. This is the salt used to produce the fine crimson fire of the theatres, a receipt for which is given in *Ex.* 1202. The following will also show a similar, though less brilliant effect.

1244. Let a few grains be dissolved in weak spirits of wine, and then set fire to the spirit. It will in burning give the well-known red color.

1245. *Nitrate of magnesia.* $(\mathrm{Mag} + \mathrm{N}'.)$—Add nitric acid to magnesia. It crystallizes in four-sided prisms. It is deliquescent and soluble in its weight of water.

1246. *Protonitrate of manganese.*—Mix together the peroxyde of manganese, and $\frac{1}{2}$ its weight of sugar, add to this mixture nitric acid. The sugar abstracts oxygen, carbonic acid is evolved, and a protonitrate of the metal is formed.

1247. *Protonitrate and pernitrate of iron.*—Add very dilute nitric acid to iron filings. The liquid will at first be brown from its containing nitric oxyde, but when this has escaped from exposure to the air, it becomes of a pale green. Further exposure changes it into the pernitrate. This last salt may be obtained at once by adding strong nitric acid to iron filings.

1248. *Nitrate of zinc.* $(\mathrm{Z} + \mathrm{N}'.)$—Add zinc to dilute nitric acid. It is deliquescent, soluble in water and alcohol, and crystallizes with difficulty in four-sided prisms.

1249. *Nitrate of tin.*—Add tin to dilute nitric acid. It forms a yellow solution which does not crystallize, and which is decomposed both by heat and exposure to the air.

1250. *Nitrate of cobalt.*—Add cobalt to dilute nitric acid. It is a reddish brown deliquescent salt.

1251. *Nitrate of nickel.*—Add nickel to dilute nitric acid. It is a most beautiful bright green colored salt, soluble in water and alcohol.

1252. *Nitrate of copper.*—A salt of a beautiful blue color is made by dissolving copper in dilute nitric acid. *Ex.* 13 shows a very singular property of this nitrate.

1253. *Subnitrate of copper.*—Heat the nitrate of copper, with a temperature somewhat above that of boiling water, part of the acid will be decomposed, and a subnitrate be left.

1254. *Nitrate of lead.* $(\mathrm{Pl}+\mathrm{N}'.)$—Dissolve lead in dilute nitric acid, taking care to add no more lead than the acid will dissolve. It is a white, hard, translucent salt, in the shape of four and eight-sided crystals, soluble in water, but not in alcohol. This salt is much used in testing for the presence of sulphuric acid, and for detecting the chlorides, iodides, and bromides.

1255. *Dinitrate of lead.* $(\mathrm{Pl}\,2+\mathrm{N}'.)$—Boil a mixture of equal weights of nitrate and protoxyde of lead in water, filter while hot, and set aside to crystallize.

1256. *Nitrate of antimony.* $(\mathrm{Ant}+\mathrm{N}'.)$—This salt cannot be made by the direct action of nitric acid upon metallic antimony, because the action is so powerful that the acid is decomposed; but it may be procured by using the protoxyde instead of the metal. It dissolves very sparingly in water, and crystallizes in white scaly crystals.

1257. *Nitrate of bismuth.* $(\mathrm{Bi}+\mathrm{N}'.)$—Dissolve the metal in nitric acid, diluted with half the quantity of water.

1258. *Subnitrate of bismuth.*—Add water to a solution of nitrate of bismuth, a fine white powder falls down. This is often called the *magistery of bismuth*, or *pearl white.* It is used as a cosmetic, and occasionally as a tonic medicament.

1259. *White sympathetic ink.*—Write on paper any words or characters, with a saturated solution of nitrate of bismuth. When dry they will be invisible, but if the paper be dipped in water, or the characters be washed over with a wet brush, they will appear of a white color.

1260. *Protonitrate of mercury.*—Dissolve mercury in nitric acid, diluted with 3 times its bulk of water, and suffered to get cold before it is used. No more metal must be added than the acid can dissolve. The solution deposits crystals of the protonitrate of mercury. The salt may be purified by solution of the crystals in water, and recrystallizing them. This salt is valuable as a test.

1261. *Pernitrate of mercury.*—Dissolve mercury in hot and strong nitric acid, nitric oxyde is evolved, the metal becomes peroxydized, and furnishes prismatic crystals of the pernitrate.

1262. *Subnitrates of mercury.*—Pour hot water upon the pernitrate of mercury, a yellow insoluble powder separates from it, which is a subnitrate, the *nitrous turpeth* of old writers; and a superpernitrate remains in solution.

1263. *Nitrico-oxyde of mercury.*—Expose the nitrate of mercury to heat gradually raised to redness; nitric acid is given off, and a red substance remains, consisting of peroxyde of mercury with a small portion of adhering nitrate. This is used in pharmacy as an escharotic, and is called in the London Pharmacopæia, *hydrargyri nitrico-oxidum.*

1264. *Nitrate of silver.*—Add silver to nitric acid diluted with 3 times the quantity of water. It will be rapidly dissolved, with the extrication at the same time of nitric oxyde gas. If the acid and metal are both pure, the solution will be quite clear and colorless.

1265. *Lunar caustic.*—Let some crystals of nitrate of silver be fused in a silver crucible, and when in a liquid state, let the mass be poured into small cylindrical moulds. It is now the ordinary *lunar caustic*, otherwise called *argenti nitras* and *lapis infernalis.* It is much employed in medicine, occasionally as an internal remedy, but more frequently as an external caustic application, and is well known as producing a black mark upon the skin.

Decomposition of by phosphorus. See *Ex.* 406.

1266. *Decomposition of by charcoal.*—Throw a few grains of nitrate of silver upon burning charcoal, the salt will be decomposed with an extrication of light and heat, and metallic silver be deposited on the charcoal.

Decomposition of by hydrogen. See *Ex.* 253.

Decomposition of by other metals. See *Ex.* 129.

Deflagration of with phosphorus. See *Ex.* 40.

Deflagration of with sulphur. See *Ex.* 41.

Deflagration of with charcoal. See *Ex.* 44.

Arbor Dianæ, or silver tree. See *Ex.* 125, 126, 127, 130, 131.

1267. *Effect of light upon.*—Cover a piece of marble with a very thin coat of wax, scratch through this waxen ground any figure or writing, then when the marble is laid bare in these lines, paint it over with a camel-hair brush, dipped in nitrate of silver, and afterwards expose it to a strong sun light. The effect will be a black stain wherever the solution of nitrate has touched. If two or three coats of solution have been thus applied, the silver will be reduced in a metallic form, and being polished will have the appearance of the brightest silver. Ivory may be stained in the same manner. See *Ex.* 134. Spirits of turpentine will afterwards remove the ground.

Use of in photography. See *Ex.* p. 118.

The property of nitrate of silver becoming black when exposed to the air, occasioning it to be much used in the indelible ink for marking linen, as well as the various hair dyes; the following receipts are given upon these subjects:—

1268. *Indelible ink for linen.*—Dissolve ¼ of an ounce of nitrate of silver, and half that quantity of gum arabic in an ounce of water, colored by Indian ink, sap-green, or lake. First moisten the cloth with a solution made by putting an ounce of the carbonate of soda and 1 dram of gum arabic in 2 ounces of water. When the cloth is again dry, write with the ink of nitrate of silver, and expose the word written to daylight; in a very short time it will turn of a full and imperishable black color.

1269. *Hair dyes.—Hassan's dye*, or the *Grecian water*, is merely a solution of nitrate of silver, so is also *Rowland's essence of Tyre;* being disguised by coloring matter.

1270. *Detonating silver.*—This compound is not to be confounded with the fulminate of silver, or fulminating silver to be alluded to hereafter, but is described and made thus:—Dissolve silver in pure nitric acid, and pour into the solution while going on a sufficient quantity of strong alcohol; or add alcohol to a nitric solution of silver, with a considerable excess of acid. In the first case the nitric acid into which the silver is put must be heated gently, till the solution commences, that is, till the first bubbles begin to appear. It is then to be removed from the fire, and a sufficient quantity of alcohol to be added immediately to prevent the evolution of any nitrous vapors. The mixture of the two liquors occasions an extrication of heat, the effervescence quickly recommences, without any nitrous gas being disengaged, and it gradually increases, emitting at the same time a strong smell of nitric ether. In a short time the liquor becomes turbid, and a very heavy white crystalline powder falls down, which must be separated when it ceases to increase, and washed several times with small quantities of water. If a very acid solution of silver previously made be employed, it must be heated gently, and the alcohol being then added, the powder is immediately separated. The young chemist is reminded that great care is requisite in mixing alcohol with hot nitric acid, as explosion is likely to ensue, therefore only small quantities at a time must be made use of."—*Ure.*

1271. Submit a grain or two of the precipitated powder to a gradual heat, it will explode with a sharp detonation.

1272. Wrap a few grains of it up in a piece of paper, place it on an anvil, and give it a blow with a moderate sized hammer, it will explode.

1273. On to a few grains of detonating silver let fall from the end of a glass rod a drop of strong sulphuric acid, it will suddenly take fire, and the acid be scattered to a considerable distance. As this acid is very corrosive, this experiment must be performed in the open air, and with the face shielded with a mask.

HYPOSULPHITES, SULPHITES, AND SULPHATES.

The hyposulphites are a class of salts easily decomposed by heat, and by the admixture of other acids. The sulphites or salts of the sulphurous acid have also but little permanence, exposed to a moist atmosphere. Dissolved in water, in sulphuric acid, or in any thing which will communicate oxygen to them, this element will be absorbed, and the solution become that of a *sulphate*. The same want of permanence may be adduced of the hyposulphates, they becoming when heated also neutral sulphates. These three classes of salts therefore are but little used, compared to that important class the sulphates. The characters of these are to be generally soluble in water, and to throw down a precipitate with any soluble salt of barytes, which precipitate is not soluble in any other acid or in an alkali. They are decomposed by a red heat, except those of potass, soda, lithia, lime, baryta, and strontian.

1274. *Hyposulphite of potass.* (Hypos″ + Pot.)—Add sulphurous acid to the hyposulphuret of potass, and evaporate until a pellicle forms upon the surface; set it aside to crystallize. When cold, fine needle-shaped crystals of the hyposulphite will be deposited, of a cooling bitter taste, and deliquescent in the air; they may be purified by washing with alcohol, and very careful and slow drying.

1275. *Second method.*—Boil a sulphite of potass with sulphur.

1276. *Third method.*—Dissolve sulphuret of potassium in alcohol, let this solution be freely exposed to the air, and after some time let it be washed in alcohol; this will carry away the adhering sulphuret, and leave the crystals of hyposulphite.

1277. Expose a few crystals of the hyposulphite of potass to a gradually increasing heat on an iron shovel; it will soon take fire, and be consumed by a slow smouldering combustion.

1278. *Sulphite of potass.* ($S'' + \text{Pot.}$)—Add sulphurous acid to a solution of potass, or its carbonate, and evaporate without contact with the air. It crystallizes in white rhomboidal plates or prisms, soluble in their weight of cold water. Exposed to the air they are converted into the sulphate.

1279. *Hyposulphate of potass.* ($\text{Hypos}' + \text{Pot.}$)—Add a boiling hot solution of sulphate of potass to the hyposulphate of baryta; a decomposition of the latter will take place, and the sulphate of baryta and hyposulphate of potass be formed, the sulphate will fall down as an insoluble white powder; the hyposulphate which is soluble in hot water, and very little so in cold water, may be obtained by filtering the supernatant liquor while still hot, and letting it then cool quickly as much as possible out of contact with the air.

1280. *Sulphate of potass, vitriolated kali, &c.* ($S' + \text{Pot.}$)—There are many ways of making this common and cheap salt; the simplest is by adding dilute sulphuric acid to potass, or the carbonate of potass. It may be afterwards evaporated and crystallized. Its crystals are octöhedral, or sometimes six-sided prisms, terminated by six-sided pyramids. It is stated that the crystals while forming sometimes emit a yellow light. It dissolves in 16 parts of cold and 5 of boiling water. If there be but little water present when mixing the sulphuric acid and the potass, the sulphate formed will fall as a white powder.

1281. *Pyrophorus.*—Take 2 parts of the sulphate of potass and 1 of lamp black, reduce them both to a fine powder, and let the two be intimately mixed; then place them in a glass phial, and cover the outside of the phial with a thick coating of clay, place it in the fire and keep it red hot for a few minutes, then take it out and cover the mouth of the phial with a piece of clay. In this state let it get cool, when the coating of clay may be taken off and the phial corked. When a few grains of this powder are afterwards let fall from the phial, they will take fire spontaneously upon coming in contact with the air, forming what is called a *pyrophorus*. This mixture appears to contain potassium, which rapidly attracting oxygen from the air, excites heat sufficient to inflame the other ingredients.

1282. If the proportions of the ingredients thus heated are 5 parts of sulphate of potass to 1 of lamp black, the result will be the sulphuret of potassium. The sulphuric acid is decomposed, its oxygen unites with the carbon, forming carbonic acid gas, which flies off, while the sulphur unites with the liberated potassium, the oxygen constituting it potass or the oxyde of potassium, combining with the charcoal at the same time.

1283. *Bisulphate, or supersulphate of potass.* ($\text{Pot} + S'^2$.)—Boil sulphate of potass with half its weight of sulphuric acid. It is decomposed when united with water, crystals of the common sulphate being deposited upon the evaporation of such a solution, the liquor itself remaining sour.

1284. *Second and more common mode of manufacture.*—Put into an earthenware still equal weights of sulphuric acid and saltpetre, distil them together, as explained in the manufacture of nitric acid, *Ex.* 795. The bisulphate of potass is left in the still. Thus procured, it is the well-known material called *sal enixum*, and is much used for cleaning brass and other metallic work previous to lackering and other finishing processes, also for cleaning coins.

1285. *Sesquisulphate of potass* obtained by the same process as the bisulphate, the proportions of the nitre and acid, being equal parts of both.

1286. *Hyposulphite of soda.* ($\text{Sod} + \text{Hypos}''$) made in the same way as the hyposulphite of potass, and having the same general properties. It readily dissolves the chloride of silver, and thus is useful in photogenic drawing. See p. 120.

1287. *Sulphite of soda.* ($\text{Sod} + S''$.)—Boil the sulphate of soda with sulphuric acid. It may be obtained in four or six-sided flat prisms.

1288. *Hyposulphate of soda.* ($\text{Sod} + \text{Hypos}'$.)—Decompose the hyposulphate of baryta, by adding to its solution the sulphate of soda.

1289. *Sulphate of soda, Glauber's salts, sal mirabile.*—This is the substance left in the retorts used for the manufacture of hydrochloric acid or chlorine, or in any process wherein sulphuric acid is added to common salt. See *Ex.* 860. It may also be formed by adding sulphuric acid to the carbonate of soda. This salt contains so much water, that when heated it parts with 50 or 60 per cent.

Sudden crystallization of. See *Ex.* 187 and 188.

Form of the crystals of. See *Ex.* 184.

1290. *Bisulphate and sesquisulphate of soda*, obtained in the same manner as the bisulphate and sesquisulphate of potass.

1291. *Hyposulphite of lime.* (Hypos$''$ + Lime.)—Rub together in a mortar crystals of the hydrosulphuret of calcium and sulphurous acid; the peculiar strong smell of the latter disappears, and being filtered, is found to be a solution of the hyposulphite. If the salt be required in crystals, it must be evaporated by a heat not exceeding 140°, otherwise it will be decomposed. The crystals are little altered by air, soluble in water, but not in alcohol.

1292. *Sulphite of lime.* (S'' + Lime.)—Pass sulphurous acid into a mixture of lime and warm water, or else mix together solutions of the chloride of calcium and sulphate of potass.

1293. *Hyposulphate of lime.* (Hypos$'$ + Lime.)—Add to a solution of lime, or rather a mixture of lime and water, the hyposulphate of magnesia; decomposition takes place, and the hyposulphate of lime is formed, magnesia at the same time being deposited. The solution must be filtered, and set aside to crystallize.

1294. *Sulphate of lime,* (Lime + S',) *gypsum, selenite, alabaster, plaster of Paris, &c.*—Add sulphuric acid to common salt, or else to lime, a white insoluble powder is formed. Heated red hot, it becomes afterwards rapidly absorbent of water, and is thereby solidified into a united mass, during which process of solidification considerable heat is extricated. This peculiar character of solidifying renders calcined plaster of Paris so valuable for casts and moulds of various kinds, for imitative statues and gems, models, and for joining stone, glass, and other bodies together, for bas reliefs, busts, architectural and garden ornaments, &c., The following remarks and directions for working in plaster of Paris may be serviceable.

WORKING IN PLASTER.

Casting in plaster and sulphur are converse operations, moulds in sulphur are used to cast in plaster and moulds of the latter material, for the casting of sulphur; therefore in describing the present art, we must refer to the other which is fully illustrated on p. 55 and 56.

1295. *Casts of gems, &c.*—The moulds being prepared as before described under sulphur, it is now merely requisite to consider how to produce a medallion similar to that from which it was cast, and this is to be done in plaster of Paris—the choice of which for the purpose requires attention. That plaster which is usually employed by the plasterers, and sold at various oil-shops, is only adapted for the coarsest work, such as the various parts forming moulds of large figures, busts, pieces of statuary, &c., and even in these a thin inner coat of finer plaster is necessary. That kind used for the making of medallions, plaster figures, and architectural models, is called superfine plaster, and can be bought only at the manufacturers, or at the Italian figure makers. (Of the latter class two live in Drury Lane—one in Russell Street, one in Frith Street, Soho—and several in Liquorpond Street; who sell it in bags, or half bags, at about 1*s.* each.)

1296. *To prepare the moulds.*—Take a small piece of wadding, make it damp with clean sweet oil, and rub it over the face of the sulphur mould, making this wet with oil, but not so wet as that the oil shall lay upon it in drops, or fill up the cavities—a uniform thin surface of oil being all that is requisite. When you have oiled a number of the moulds in this way, (say twenty of them,) surround each with a strip of hard paper, and fasten the end of it with paste or a wafer. The moulds will now be ready for use.

1297. *To cast upon them.*—Pour some water in a basin to about three parts full, and *sprinkle* into it as much of the plaster as you think will suffice for the moulds which have been prepared, to cover each a quarter of an inch in thickness. When the plaster has been sprinkled in, pour off all the water which floats above it, and with a spoon, (not iron,) stir up the plaster, which will now be found as thick as honey; put about a tea spoonful into each of the moulds; and as quickly as possible afterwards brush it with a small stiff-haired brush into all the depressions of the mould. This is best done by holding the brush upright, and slightly beating the plaster with the points of the hairs. Then immediately afterwards, and before the plaster begins to set, or to get hard, fill up each mould to the requisite thickness, and as each is filled take it up in the left hand, (supposing the spoon to be in the right,) and tap the bottom of it gently upon the table four or five times, merely to shake the plaster down evenly, so as to present a level surface at the top, and to prevent holes appearing upon the face. The cast is now completed, and will in a few minutes become sufficiently hardened to be removed from the mould, when it will only require trimming with a knife around the edges, and gradually drying. Oiling the moulds each time, any number of casts may be made in the same manner.

The time which plaster of Paris takes to set varies extremely—when very fresh it will be, perhaps, five minutes—when rather more stale, it will often set so rapidly, that it is extremely difficult to use it quick enough. When still longer kept it will gradually lose its power of setting altogether; and not only so, but become rotten and wholly unfit for the purposes of the caster. Some of the above inconveniences may be remedied as follow: If it set too quick for the object in view, put a very small quantity of size, or thin glue, in the water used, (a large spoonful of melted size is enough for a pint of water.) If you desire it to set rapidly, use warm water instead of cold. This is necessary when a cast of the face is to be taken—if you desire it to be very hard, and yet set quickly, mix it up with some strong alum water. Plaster when once it has begun to set, should never be disturbed, and never can be mixed up a second time, therefore, the basin, spoon, and brush, must always be carefully washed between each casting. The casts made can only be imperfect in one way; that is, in having air bubbles on their surface. These arise either from the plaster when poured on being too thin, or else not well shaken down—a very little attention, therefore, will remedy the defects at a subsequent casting.

1298. *Coloring the casts.*—Plaster medallions are often colored, even sometimes gilt, and still more frequently polished. These processes are all simple. The painting of them is of two kinds: in one the figures and prominences are left white, and the flat ground is colored either with *emerald green*, smalt blue, or lamp black, made glossy by the addition of gum water, and laid on with a common camel's-hair pencil. In the other case of painting all the objects are colored with common water colors, according to their natural appearances. In this painting all the caution necessary to be observed is to use no color that can be decomposed by the plaster of Paris. Thus, in making a green for trees, grass, &c., employ indigo and not Prussian blue, for in a few days, by the partial decomposition of the latter color, the green becomes yellow. Plaster casts may be gilt by rubbing them over with the white of egg, and immediately putting upon them some gold leaf, which will adhere firmly.

1299. *Polishing the casts.*—They are polished or made glossy on the surface, thus:—Take some white curd soap and dissolve it in water, so as to make a strong solution. Pour a little of this in a saucer, and immerse the face of the medallion three or four times, letting it dry for a minute or two between each immersion. Put it aside till the next day, and then gently rub the surface with a small piece of wadding, or loose cotton, when a very smooth, beautiful and glossy surface, will appear upon it. They will now be much less liable to attract dust, moulds may be made from them as before, and if dirty may even be slightly washed without injury, polishing them again only when they are perfectly dry. In this manner the Italians have lately polished the surface of many figures they are accustomed to make. The reason of this effect must be evident to the chemist. The soap is decomposed by the plaster, the alkali of the soap is taken up by the sulphuric acid of the plaster, and the other constituent of the soap, namely, grease, is set at liberty, and remains as a glossy coat upon the surface. If it be desired to bronze a plaster figure, or medallion, paint it over with a mixture of Indian ink, indigo, and gamboge, or, still better, Indian yellow; so as to be of a dark and uniform olive color. Touch the more prominent parts with bronze powder, and varnish the whole over carefully, so as not to disturb the powder, with a weak solution of dragon's blood dissolved in spirits of wine; and if well done they will appear as fine as any of the bronze medals of antiquity, though not so clear in their details; nor, (owing to their coat of color,) so sharp as medallions made of sulphur, previously described.

If plaster is at any time to be cast out of a plaster mould, the latter must be well greased before using, or if the moulds have been previously boiled in wax and grease, as recommended by some persons, or washed over with this mixture in a boiling state, oiling will alone be necessary. A very thick solution of soap will answer to separate the two surfaces. This is used by modellers.

1300. *Casting from leaves.*—The leaf, as soon as convenient after being gathered, is to be laid on fine-grained moist sand, in a perfectly natural position; having that surface uppermost which is to form the cast; and being banked up by sand, in order that it may be perfectly supported. It is then by means of a broad camel-hair brush, to be covered over with a thin coating of wax and Burgundy pitch, rendered fluid by heat. The leaf being now removed from the sand and dipped in cold water, the wax becomes hard, and at the same time sufficiently tough to allow the leaf to be ripped off without altering its form. This being done, the wax mould is placed on moist sand, and banked up as the leaf itself was; it is then covered with plaster of Paris made thin, care being taken that the plaster is accurately forced into all the interstices of the mould by means of a camel-hair brush. As soon as the plaster is set, the warmth thus produced softens the wax, which in consequence of the moisture of the plaster is prevented from adhering thereto; and with a little dexterity it may be rolled up, parting completely from the cast, without injuring it in the smallest degree.

Casts thus obtained are very perfect, have a high relief, and are excellent models, either for the draughtsman, or for the moulder of architectural ornaments.

1301. *Moulds for waxen fruit, fossils, &c.*—Suppose we desire a mould for an apple and we have a real one to mould from, press down the apple into damp sand, until very nearly one-half of it is buried, that is until the sand reaches to the thickest part: in an apple this would be near the middle; in a pear near one end, unless it were put sideways, when in this case it would also be one-half. An apple must not be put sideways, because it would not then deliver, that is when the upper part is surrounded with the hardened plaster, as it is soon to be, it cannot be drawn out, on account of a depression there generally is at the stalk and eye of an apple; but by placing it the other way, that is either stalk or eye end downwards, this difficultly is avoided. In making moulds of every description this is above all things to be observed; even in such simple objects as those now under consideration it is of the utmost necessity. But to proceed—The apple being nearly half sunk in the sand, bend a piece of tin into a hoop, so as to be an inch or inch and a half larger across than the apple; tie a piece of string around it, and place it over the apple, forcing its lower edge into the sand so as to hold it firmly. Then pour the plaster mixed in the former method upon it, in a minute or two it will become sufficiently set, or hardened, to be handled. When this is the case remove the tin, and take up the fruit out of the sand altogether, there being now one half of the mould cast. This must be trimmed with a knife for the sake of appearance; and particularly where the sand has touched, cut carefully smooth at the exact half of the fruit, for it will have been observed, that as the apple was not quite half buried in sand, the part of the mould now cast will be rather more than half, a small part being allowed for cutting away evenly. Now make a hole or two, or a few notches, on one side of the cast where the other is to join it; grease well or soap well this part, holes and all, and tie round it tightly a piece of tin or paper. The fruit will now be in the same position, in respect to the half mould, as it was when in the sand, except that it is now the other end upwards. The only thing remaining to be done is to pour plaster upon this other end, and the mould will be complete, except a little trimming which it will require. The parts will easily separate at the joint, and taking out the real fruit, a cavity will of course be in its place, of the exact size and shape.

Those fruits which have hard or rough skins require greasing to prevent the plaster sticking to them; this is the case with the peach, the apricot, the walnut and other nuts, the almond, &c. &c. There are some few fruits which require the mould to be in three pieces, as very often the melon, the mulberry, and blackberry. Other fruits are never made in wax, as grapes, currants, and many more of the smaller kinds, on account of the trouble of joining them together afterwards in bunches.

1302. *To take a cast from the living face.*—This is often done as a mould for a bust or to preserve a likeness of a person—the art requires only a little care. Let the person a mould of whose face is to be taken, lay down upon their back, let the hair be tied back, or otherwise kept back by grease, or by flour dough placed on it; grease the eyebrows, and if necessary the beard and whiskers, also anoint the rest of the face with sweet oil. Then place a quill in each nostril, keeping it there with dough. Tie a towel round the face and make it fit tight with dough also. The patient being thus prepared, mix up the required quantity of plaster of Paris, with warm water, and just as it is ready to set pour it upon the face, taking care that the eyes and mouth are closed, and the outer ends of the quills above the plaster. Use a pallet knife to spread the plaster evenly over all parts of the face, until a coat is formed half an inch or more in thickness. In about two minutes it will set sufficiently hard to be removed. When dry and well greased, a cast in plaster may be taken from the mould, or if wetted, a cast in wax may be taken with equal facility. A little warm water will remove the dough, &c. from the face. In this manner casts are often taken of tumours and skin diseases, the wax casts being afterwards colored. For wax casts, a good composition is white wax, 1 pound; turpentine in lumps, 2 ounces; flake white, 2 ounces, and vermillion to color the whole.

1303. *To transfer engravings to plaster casts.*—Cover the plate with ink, and polish its surface in the usual way, then put a wall of paper round it, and when completed, pour in some finely powdered plaster of Paris, mixed in water; jerk the plate repeatedly, to allow the air bubbles to fly upwards, and let it stand one hour, then take the cast off the plate, and a very perfect impression will be the result.

1304. *Hyposulphite of baryta.* ($\text{Hypos}'' + \text{Bar.}$)—Pour a solution of chloride of barium into a strong solution of hyposulphite of lime. It is a white powder.

1305. *Sulphite of baryta.* ($\text{S}'' + \text{Bar.}$)—Add sulphurous acid to a solution of chloride of barium, or else add the sulphite of potass to the same chloride.

1306. *Hyposulphate of barium.* ($\text{Hypos}' + \text{Bar.}$)—Pass sulphurous acid gas into a thin paste of water mixed with the peroxyde of manganese; two salts are obtained, the hyposulphate and the sulphate. The latter will subside along with the manganese, which is now changed into the protoxyde. The former or the hyposulphate being a soluble salt will not precipitate, but may be obtained by filtering and evaporating the filtered liquid. It may be purified by washing with alcohol in which it is insoluble.

1307. *Sulphate of baryta.* ($S' + \text{Bar.}$)—Sulphuric acid and barytes, have a stronger affinity for each other than either has for any other substance; therefore if baryta be added to a solution of any sulphate except its own, such sulphate will be decomposed, and a sulphate of baryta be formed; as this is perfectly insoluble in hot and cold water, it will fall to the bottom of the solution as a white heavy powder.

1308. Also if any soluble salt of baryta, such as the chloride, chlorate, or nitrate be added to sulphuric acid, or to a sulphate, the same result takes place, and the sulphate of baryta is formed; hence the value of this and other salts of barium in detecting sulphuric acid.

1309. *Permanent white.*—This valuable pigment, the white color of which is not tarnished by sulphuretted hydrogen, or any other fumes, and therefore used to paint upon chemical bottles, &c., is the sulphate of baryta, obtained by adding carbonate of baryta to the sulphate of potass, or when wanted in large quantities, it is made by purifying the native sulphate of baryta, an abundant natural product, called also ***heavy spar***, ***ponderous spar***, and ***marmor metallicum***.

1310. *Bologna phosphorus.*—Form the sulphate of baryta into a thin cake with common flour paste. Heat this cake to redness in a crucible, it will thus acquire the property of being phosphorescent in the dark.

1311. If sulphuric acid be poured upon some fresh calcined and consequently caustic baryta, the combination will be so rapid that the mixture will become of a glowing red heat.

1312. *White enamel.*—The sulphate of baryta is the substance employed to produce white figures and lines upon colored china and glass. The lines required white are painted with this powder mixed to a proper consistence with oil, and used in the manner of paint. It is afterwards subjected to the strong heat of a furnace, when it fuses into a white enamel.

1313. *Hyposulphite and sulphite of strontia.*—Pass sulphurous acid into a solution of the sulphuret of strontia. It will first change to the hyposulphite, and afterwards to the sulphite. Either of these by exposure to the air changes to the sulphate.

1314. *Sulphate of strontia.* ($\text{Str} + S'.$)—Add sulphuric acid to the earth strontian, or else add the solution of a soluble sulphate or sulphuric acid to any other salt of strontia. It is similar in its properties to the corresponding salt of baryta.

1315. *Hyposulphite of magnesia.* ($\text{Hypos}'' + \text{Mag.}$)—Boil flowers of sulphur in solution of sulphite of magnesia.

1316. *Sulphite of magnesia.* ($S'' + \text{Mag.}$—Pass sulphurous acid through water holding magnesia in suspension.

1317. *Hyposulphate of magnesia.* ($\text{Hypos} + \text{Mag.}$)—Mix together solutions of the sulphate of magnesia and hyposulphate of baryta.

1318. *Sulphate of magnesia. Epsom salts.* ($S' + \text{Mag.}$)—Is obtained principally from the water left after the extraction of salt from sea water. It may be made artificially by adding sulphuric acid to magnesia, or its carbonate, when added to the former, fresh calcined, great heat is extricated. Sulphate of magnesia is one of our most valuable purgatives.

1319. *Hyposulphite of manganese.*—Add hyposulphite of lime to the sulphate of manganese.

1320. *Sulphite of manganese.*—Pass sulphurous acid through a mixture of carbonate of manganese and water, till the carbonic acid is expelled.

1321. *Hyposulphate of manganese.*—Pass sulphurous acid through a mixture of water and the peroxyde of manganese. The hyposulphate which is a soluble salt is obtained.

1322. *Sulphate of manganese.*—Mix the peroxyde of manganese into a paste with sulphuric acid, and subject it to nearly a red heat in a crucible, they will unite and form a white mass, from which, if water be added, a sulphate will be obtained. The crystals are of a pink color.

1323. *Hyposulphite of protoxyde of iron.*—Dissolve iron filings in sulphurous acid. The solution is at first brown, then green. Although readily decomposed by exposure to the air, yet if a few filings of iron be kept in it, it may be retained in corked phials, unchanged for a length of time.

1324. *Hyposulphate of iron.*—Mix together the solutions of hyposulphite of baryta and of the protosulphate of iron. Sulphate of baryta will fall down, and upon the supernatant liquor being filtered, green crystals of the hyposulphate of iron will be obtained.

1325. *Sulphates of iron.*—There are two sulphates of iron, the protosulphate and the persulphate. A solution of the former of which, so well known as ***green vitriol*** or ***copperas***, gradually absorbs oxygen, and becomes changed into the persulphate; yet crystals of the protosulphate, upon exposure to a dry atmosphere, become covered on the surface with a reddish colored deutosulphate. The protosulphate is usually obtained by exposing roasted *pyrites*, which is the bisulphuret of iron, to alternate air and moisture, when they become gradually converted into this salt, though as such retain generally an excess of sulphuric acid; this must be neutralized by immersing iron plates in the solution. The crystals are of a transparent green color, and are much used in dyeing and the manufacture of ink.

1326. Drop some crystals of the protosulphate of iron in strong sulphuric acid, they will not dissolve, but be converted into a perfectly white powder, which will fall to the bottom of the acid. The same is the case when strong alcohol is used. The reason of this change is merely that these menstrua deprive the salt of its water of crystallization.

1327. *Hyposulphite of zinc.*—Pour sulphurous acid upon filings of metallic zinc, then add alcohol, which will dissolve the hyposulphite from it; it may be obtained by evaporation.

1328. *Sulphite of zinc.*—Dissolve the white oxyde of zinc in sulphurous acid. This is insoluble in alcohol.

1329. *Hyposulphate of zinc.*—Add a solution of hyposulphate of baryta to sulphate of zinc.

1330. *Sulphate of zinc.*—Add dilute sulphuric acid to metallic zinc. Hydrogen is evolved as in *Ex.* 245. For the purposes of the arts, when it is called *white vitriol*, it is obtained from the native sulphuret of zinc, by exposure to air and moisture.

1331. *Trisulphate of zinc.*—Boil zinc in a solution of the sulphate.

1332. *The other metallic hyposulphites, sulphites, and hyposulphates* are seldom required; several may be obtained in the manner already shown of those above mentioned. The sulphates of the rest of the important metals will suffice as notices of their character and mode of manufacture.

1333. *Sulphate of tin.*—Boil tin in dilute sulphuric acid; the solution affords by evaporation white needle-shaped crystals of the protosulphate of tin. If the peroxyde of tin be used instead of metallic tin, a persulphate is obtained. If water be added to these salts, they are decomposed, and fall down as a white powder of the peroxyde of tin, so little is the affinity between sulphuric acid and this metal.

1334. *Sulphate of cobalt.*—Dissolve the protoxyde or the carbonate of cobalt in sulphuric acid, diluted with its bulk of water. It is of a blue color when much dried, but the solution is pink. If subjected to a red heat, the crystals fuse, part with their acid, and leave a black oxyde.

1335. *Sulphate of nickel.*—Dissolve the oxyde or carbonate of nickel in dilute sulphuric acid; the solution is of a bright green color. The crystals when heated crumble into a yellow powder.

1336. *Sulphate of copper, blue vitriol, blue stone, Roman vitriol, &c.*—Dissolve the peroxyde of copper in sulphuric acid, or else boil copper filings in sulphuric acid. It is obtained for purposes of commerce from the native sulphuret or copper pyrites in the same manner as the sulphate of zinc is made. It is much used in the arts for precipitation by the electrotype, as a source of numerous pigments and dyes, and in medicine as an external caustic application, and occasionally as an emetic, in which action it is very powerful.

1337. *Sulphate of lead.*—Boil metallic lead in strong sulphuric acid, at a less temperature the acid will have no effect upon the metal. It may be made also by adding Epsom salts or Glauber's salts to the acetate, (sugar of lead.) Thus persons poisoned by taking sugar of lead are relieved by afterwards swallowing a dose of Epsom salts, which converts the acetate of the metal into a sulphate, which is harmless. It may also be procured from the nitrate of lead by adding an alkaline or earthy sulphate to it.

1338. *Sulphate of antimony.*—Boil metallic antimony in strong sulphuric acid; adding water to the solution resolves it into two salts—a subsulphate which being insoluble falls to the bottom, and supersulphate which remains in solution, and which by proper evaporation may be crystallized.

1339. *Sulphate of bismuth.*—Obtained and decomposed in the same manner as the sulphate of antimony.

1340. *Protosulphate of mercury.*—Digest mercury in strong and hot sulphuric acid in the proportion of 1 part metal to 1½ acid; the result will be a white mass, which, when washed in cold water, yields a white salt, so insoluble that a great portion of it falls in powder, or minute prismatic crystals. This is the protosulphate.

1341. The same salt is obtained when sulphuric acid or sulphate of soda is added to a solution of the protonitrate of mercury.

1342. *Supersulphate of mercury.*—Dissolve the above protosulphate in sulphuric acid.

1343. *Persulphate of mercury.*—Boil the solution of the supersulphate for some time in sulphuric acid, and a persulphate will be obtained. Upon the addition of water, it is resolved into a soluble *supersalt* and an insoluble *subsalt*. The latter washed in boiling water acquires a yellow color, and is then known as *turpeth mineral*. It is a dangerous emetic.

1344. *Sulphate of silver.*—Boil silver with sulphuric acid, or add sulphate of potass to a solution of the nitrate of silver.

1345. *Protosulphate of platinum.*—Digest by the assistance of heat the protochloride of platinum in sulphuric acid.

1346. *Persulphate of platinum.*—Add nitric acid to the sulphuret of platinum; the acid will be decomposed, yielding its oxygen to the sulphur, which at the same time dissolves the platinum, while nitrogen escapes.

HYPOPHOSPHITES, PHOSPHITES, AND PHOSPHATES.

The few hypophosphites and phosphites which have been examined are chiefly those of the alkaline and earthy metals, and even these are comparatively of little interest. They are for the most part white, soluble in water, but crystallized with difficulty. They smell strongly of phosphorus, and are decomposed at a moderate heat, giving off phosphuretted hydrogen. Of the phosphates some are soluble, others insoluble; they may easily be procured by dissolving the metallic oxydes in phosphoric acid, and very often one phosphate may be procured by the decomposition of another.

1347. *Hypophosphite of potass.*—Mix a solution of hypophosphite of lime with one of carbonate of potass, filter and evaporate to dryness. Then pour alcohol upon the residuum, this will dissolve the hypophosphite of potass; from this solution it may be procured by evaporation; it is then a white powder.

1348. *Phosphate of potass.*—Add phosphoric acid to a hot solution of carbonate of potass. It is not soluble in alcohol.

1349. *Diphosphate of potass.*—Add hydrate of potass to a solution of the phosphate, evaporate, and then remove the excess of potass by alcohol. It is thus procured a gritty white powder, tasteless, insoluble in cold water, but soluble in hot.

1350. *Biphosphate of potass.* (Pot + Ph'2)—Dissolve the neutral phosphate in phosphoric acid, and evaporate till crystals are obtained.

1351. *Hypophosphite of soda.*—Obtained in like manner with the hypophosphite of potass.

1352. *Phosphate of soda.*—Dissolve the carbonate of soda in phosphoric acid. This is the *sal perlatum*, or *rhombic phosphate* of old authors, and has been used in medicine under the name of tasteless purging salt. It is soluble in 4 parts of cold and 2 of hot water.

1353. *Pyrophosphate of soda.*—Heat the phosphate to redness, then dissolve in water and crystallize. It now assumes a new form, and precipitates silver from the nitrate as a white powder, the pyrophosphate of silver; instead of yellow, when it is the neutral phosphate.

1354. *Biphosphate of soda.*—Add phosphoric acid to a solution of phosphate of soda until it ceases to precipitate chloride of barium.

1355. *Hypophosphite of lime.*—Boil phosphorus in a mixture of lime and water,—filter, and pass carbonic acid through it to separate excess of lime. This is useful in preparing the other hypophosphites.

1356. *Neutral phosphate of lime.*—This is a natural product, so abundant in Estramadura, that even houses are built of it. It also constitutes the chief part of the bones of all animals, and is the *burnt hartshorn* of medicine. It is used for making *cupels*, for absorbing grease from cloth, for polishing gems, &c., and for preparing phosphorus. It is insoluble in water, and very difficult to fuse. It may be made artificially by adding a solution of phosphate of soda to a solution of chloride of barium, the phosphate of lime falls down as a white tasteless powder. That salt procured by the burning of bones is said to be a subphosphate, containing a half proportion more lime than the neutral phosphate just described.

1357. *Biphosphate of lime.*—Boil phosphate of lime in phosphoric acid.

1358. *Hypophosphite of baryta.*—Boil phosphorus in baryta water, that is in a mixture of baryta and water.

1359. *Phosphite of baryta.*—"Add a solution of chloride of barium to phosphite of ammonia. A crust of phosphite of baryta was formed after 24 hours."—*Berzelius.*

1360. *Phosphate of baryta.*—Drop a solution of the neutral phosphate of ammonia into a solution of a neutral salt of baryta; as the nitrate or muriate a double decomposition takes place, the result of which is the formation of a soluble salt of ammonia, and the precipitation of a white powder which is the phosphate of baryta.

1361. *Sesquiphosphate of baryta.*—Boil phosphate of baryta in phosphoric acid to saturation, then add alcohol. Abundance of a white, light powder will subside; this is the sesquiphosphate of baryta.

1362. *Biphosphate of baryta.*—If phosphate of baryta be boiled in phosphoric acid as in the last experiment, and the addition of alcohol be omitted, the solution will form crystals of the biphosphate of baryta. Adding water to them, they are resolved into phosphate of baryta and phosphoric acid.

1363. *Hypophosphite of strontia.*—Obtained by boiling phosphorus in strontia water.

1364. *Phosphite of strontia.*—Saturate phosphorus acid with the carbonate of strontia; crystals will be formed, which are resolved into a white powder upon the addition of warm water. A second method of preparation is to mix together solutions of the chloride of strontium and the chloride of phosphorus; left to spontaneous evaporation, crystals of the phosphite of strontia are deposited.

1365. *Phosphate of strontia.*—Add phosphate of soda to the nitrate of strontia; or else subject the phosphite of strontia to a red heat. It is a white salt, insoluble in water, but soluble in excess of acid, in which circumstance it differs from the phosphate of baryta.

1366. *Hypophosphite of magnesia.*—Boil oxalate of magnesia for a long time with hypophosphite of lime; filter and evaporate. It crystallizes in octoëdral crystals.

1367. *Phosphite of magnesia.*—Mix equal parts of the solutions of phosphate of soda and sulphate of magnesia. Leave them for some time at rest, when the phosphate of magnesia will crystallize, and leave the sulphate of soda dissolved. It dissolves in 50 parts of warm water.

1368. *Subphosphate and superphosphate of magnesia.*—Add boiling water to the phosphate. The subphosphate which is insoluble will be thrown down, and the superphosphate which is soluble will be suspended in the water, and may be afterwards crystallized.

1369. Brande gives in his "Chemistry" the following curious and inexplicable experiment. He says, "If after having mixed a solution of magnesia and of phosphate of soda with bicarbonate of ammonia, and having put some of the solution into a watch glass, or on to a piece of plate glass, lines be traced upon the glass, thus covered, with a glass rod, the salt will be deposited upon the traces. This appearance, the cause of which has not been adequately explained, has been ingeniously proposed by Dr. Wollaston as a test of the presence of magnesia. A similar appearance, however, ensues in other cases of granularly crystallized precipitates, but never where they are pulverulent."

1370. *Phosphate of manganese.*—Add phosphate of soda to sulphate of manganese. It is a white, nearly insoluble, powder, decomposed by boiling with caustic potass.

1371. *Protophosphate of iron.*—Mix together solutions of protosulphate of iron and phosphate of soda. It is an insoluble powder, at first white, then bluish, soluble in many of the acids unchanged.

1372. *Perphosphate of iron.*—Use the persulphate, instead of the protosulphate of the last experiment. This also is insoluble, but after a time becomes brown, and not blue as the protophosphate does.

1373. *Phosphate of zinc.*—Add phosphate of soda to sulphate of zinc, or else dissolve zinc in phosphoric acid. It is a white, insoluble powder.

1374. *Phosphate of tin.*—Add phosphate of soda to the protochloride of tin.

1375. *Phosphate of cobalt.*—Add phosphate of soda to chloride of cobalt. This salt is of a fine lilac color, insoluble in water, but soluble in excess of phosphoric acid.

1376. *Thenard's blue, or artificial ultramarine.*—This fine blue pigment is procured by adding 1 part of the phosphate of cobalt to 2 or 3 of alumina, and bringing the mixture to a full white heat in a covered crucible. The purity of the color will be in proportion to the purity of the alumina and the phosphate, and the proper degree of heat employed.

1377. *Phosphate of nickel.*—Add phosphate of soda to a solution of the nitrate of nickel. It is of a pale green color, and subsides as a powder from the mixed solutions.

1378. *Phosphate of copper.*—Add sulphate of copper to phosphate of soda, both in solution, the phosphate of copper will be thrown down as a bluish green powder.

1379. *Phosphite of lead.*—Add chloride of lead to phosphite of ammonia, both in solution. It is a white insoluble powder.

1380. *Phosphate of lead.*—Mix together hot solutions of phosphate of soda and chloride of lead, so that there is an excess of the latter. Like most of the other phosphates, it is white and insoluble. A natural phosphate of lead is not unfrequent. This is of a yellow color, perhaps from being contaminated with the protoxyde.

1381. *Phosphate of antimony.*—Dissolve protoxyde of antimony in hot phosphoric acid. It does not crystallize, neither does it appear that this phosphate has been formed by double decomposition as so many of the others have.

1382. *Phosphate and subphosphate of bismuth.*—Digest filings of metallic bismuth in phosphoric acid. When dissolved, add water, this will dissolve the phosphate and leave a subphosphate to fall down.

1383. *Phosphates of mercury.*—Mix together the solutions of phosphate of soda and of protonitrate of mercury, the *protophosphate* of the metal will be thrown down. If the *pernitrate* of mercury be used instead of the protonitrate; the result is a perphosphate of the metal. The difference between the two is that the latter dissolves in phosphoric acid, but the protophosphate does not.

1384. *Phosphate of silver.*—Add phosphate of soda to nitrate of silver. The phosphate of the metal thrown down is of a yellow color, which is quickly discolored by exposure to light, hence it has been used in photogenic drawing.

CARBONATES.

This important class of salts, formed by the union of carbonic acid with an alkaline, earthy, or metallic base, is of essential importance in medicine and the arts. Their artificial production may be mostly accomplished by adding an alkaline carbonate to the solution of a metallic salt. The affinity however of the carbonic acid for the majority of the metals is so slight, that the addition of almost any other acid will cause their decomposition; effervescence from the escape of the carbonic acid gas at the same time taking place. From this they are known from other salts, and are valuable in the manufacture of them. Numerous of the carbonates are native productions, some are decomposed by heat, as that of lime, others suffer no change, while there are some which have a part only of their acid driven off by this agent. In the neutral carbonates the proportion of oxygen in the base is to that in the acid as 1 to 2.

Ex. 1385. *Carbonate of potass, wood-ashes, potass, pearlash, grey salts, subcarbonate of potassa,* of the "London Pharmacopæia," *salt of tartar, &c.*—This salt is so common that it is seldom necessary to manufacture it for the purpose of experiment, which may be done by passing carbonic acid gas through a solution of pure potass. Its origin and manufacture for commercial purposes is shown in *Ex.* 728.

1386. *Fluxes.*—These are materials employed to assist the fusion of the refractory metals and earthy minerals, and are combinations of the carbonate of potass. *Black flux* is made by mixing together 2 parts of powdered tartar, (bitartrate of potass) and 1 of nitrate of potass. This mixture is deflagrated in small portions at a time in an iron ladle or crucible, when it becomes of a black color, called therefore black flux. If this be dissolved in water, evaporated and crystallized, it will be found to deposit crystals of the carbonate of potass; the carbon is furnished in this experiment by the decomposition of the tartaric acid of the bitartrate. When equal parts of nitre and tartar are used, the result is a white mass called *white flux.* The reason of the difference of color is that when the greater quantity of tartar is used; more carbon is deposited than the combustion destroys, but with less tartar it is all consumed. Carbonate of potass is completely soluble in about its own weight of cold water, forming a thick oily liquid, called *oil of tartar per deliquium.* This liquid is the result also of exposing the carbonate of potass to a damp atmosphere, when it becomes deliquescent. It is insoluble in alcohol.

1387. *Bicarbonate of potass.*—Pass carbonic acid gas through a solution of the carbonate. The following is the receipt of the "London Pharmacopæia:"—

1388. "100 pounds of pure carbonate of potass are dissolved in 17 gallons of water, which, when saturated with carbonic acid, yields from 35 to 40 pounds of pure crystallized bicarbonate; 50 pounds of carbonate of ammonia are then added to the mother liquor, with a sufficient quantity of water to make up 17 gallons: a second crystallization will yield a large additional mass of the bicarbonate of potass. This salt is not deliquescent like the last."

1389. *Carbonate of soda, barilla, soda, &c.*—This valuable salt so much used of late years in washing, on account of its detergent properties, and so valuable in medicine in the formation of effervescing draughts, and as a corrective for acidity of the stomach, is manufactured in a manner similar to that of the carbonate of potass, using marine instead of terrestrial vegetables; and also from common sea salt, as explained in *Ex.* 736, 737, and 738. The carbonate of soda is not quite so soluble as the carbonate of potass, but is more fusible, and, consequently, makes a better flux and also a better glass.

1390. *Bicarbonate of soda.*—Pass carbonic acid gas into a solution of the carbonate of soda.

1391. *Carbonate of lime, marble, limestone, calcareous spar, chalk, stalactites, oolite, Portland stone, &c.* are all carbonates of lime more or less pure. That used by chemists and apothecaries, as most convenient, and called by them *Creta preparata,* is common whitening powdered.

1392. *Carbonate of baryta.*—A common natural product known by the name of *witherite.* It may be made artificially by adding the carbonate of potass or of soda to a solution of the chloride or nitrate of baryta, or to baryta water. It is highly poisonous, has no effect upon vegetable colors, and is nearly insoluble in water.

1393. *Carbonate of strontia,* obtained in the same manner as the carbonate of baryta. This is not poisonous.

1394. *Carbonate of magnesia.*—Add a solution of carbonate of soda or of potass to a solution of sulphate of magnesia, boil the mixture, and evaporate; a perfectly white powder falls; this is the carbonate of magnesia, or *magnesia alba* of pharmacy. It is necessary that each substance be dissolved in its weight of boiling water, and that the water be pure, also that the precipitate be well washed to separate the sulphate of potass held in solution.

1395. *Bicarbonate of magnesia. Magnesia water.*—Pass a stream of carbonic acid gas through a mixture of magnesia and water. It will be absorbed, and a bicarbonate be formed. This is held in solution, and cannot be crystallized. All the foregoing carbonates are of a white color.

1396. *Carbonate of manganese.*—Add carbonate of soda, or of potass, to a solution of the protochloride or protosulphate of the metal. It is at first white, but when heated becomes brown. Sometimes this, as well as the other salts of manganese, assume a pink or reddish color, owing to the admixture of a minute quantity of manganic acid.

1397. *Protocarbonate of iron.*—Add carbonate of potass to a solution of the protosulphate of iron. It is when thus made of a white color, but soon becomes greenish, and after being sometime exposed to the air brown. By this exposure it appears to be changed first to a subprotocarbonate, and afterwards to the peroxyde of iron. It cannot for the above reason be either dried or crystallized, but a native protocarbonate of iron is known as *clay iron,* and also as *spathose iron ore:* both of them more or less yellow, red, or brown.

1398. *Carbonate of zinc* occurs native as *calamine.* It may be made artificially by passing carbonic acid through water, in which is diffused the oxyde of zinc.

1399. *Carbonate of tin.*—Add carbonate of soda to the protochloride of tin. A white powder falls, which however is robbed of its acid by both water and exposure to air, or to heat, so that it cannot be dried or crystallized.

1400. *Carbonate of cobalt.*—Add an alkaline carbonate to a solution of either the nitrate, chloride, or sulphate of cobalt. It is a most beautiful powder, of a fine pink color when dry, but purple while it remains moist.

1401. *Carbonate of nickel.*—Obtained in the same manner as the carbonate of cobalt. It is a green powder.

1402. *Carbonate of copper, mineral green, verditer green, mountain green, &c.*—Dissolve in boiling water as much of the sulphate of copper as the water is capable of taking up, and while still warm add to it a solution of the carbonate of potass, which will throw down a green precipitate of the metallic carbonate. It must be washed thoroughly in boiling water. This pigment is often found native, and is known when massive by the name of *malachite.* There is also a blue carbonate of copper, made in the same manner as the above, but with cold solutions. This is called *blue verditer.* A very beautiful blue carbonate is also found native in Saxony, and other places. The green carbonate mixed with lime becomes a pulverulent blue powder, known as *copper azure,* or *mountain blue.*

1403. *Carbonate of lead, white lead.*—This valuable compound, so well known as the white powder used with and ground in oil for the purposes of the painter, is called by the various names of *ceruse, flake white, Krems white, white lead,* and others, according to the means and care employed in its preparation. It is not used in distemper color, because it is apt to tarnish and become black by the action of sulphuretted vapors, and which are of common occurrence in the atmosphere. The ceruses of commerce often contain acetate of lead, and the German is mostly mixed with sulphate of baryta. Flake white is in the purest state.

1404. *Manufacture of pure carbonate of lead.*—Add carbonate of potass to a solution of nitrate of lead.

1405. *Manufacture of.*—*Dutch ceruse* and *flake white* are prepared by exposing plates of lead to the action of vinegar steam and carbonic acid. For this purpose, earthen vessels, either glazed or hard baked, are employed; slips of wood are laid across these, and the lead in plates, or spiral forms, is placed upon them, so as not to touch the liquid which fills the bottoms of the vessels. These pots are then ranged in lines, close together, upon a bed of stable dung. Other lead being placed as tiles upon those pots, some planks are laid over them; on these are placed another layer of dung, and on this another range of pots is placed, covered with lead in like manner; and thus it proceeds until the pile is 6 or 8 feet high, as the localities may permit. To prevent the heat from becoming too powerful, openings are reserved in the layers, at proper distances, through the mass. These are usually closed, but opened occasionally to examine the temperature: when that is too high, a current of air is allowed to pass through, until the heat is brought down to the standard required, which should not exceed 100 or 120 degrees at the most, unless it may be towards the close of the operation, when it is only required to dry the carbonate which has been formed. In about six weeks the pots are removed, and the laminæ which cover them have become hard flakes, which, without further preparation, is the flake white of commerce. The spirals are unrolled, and flakes of a smaller and more brittle nature are drawn from them. These are ground in water, under horizontal grinders; the produce is then washed, and allowed to settle; the water is drained off, until the deposit has acquired a thick consistency; it is then put into conical pots, and dried for use.

This is the way in which the Hollanders prepare their ceruse. Its want of brightness arises from a small portion of the metal not being thoroughly oxydized, and also from the use of litter, which throws out vapors, by which the oxyde is darkened as it is formed. This disadvantage may be obviated by using moistened straw, or common tan, for the couches. The flakes will then have a brilliant whiteness.

1406. *Krems white.*—The addition of a substance to furnish carbonic acid is quite requisite in this preparation; but the heat of a stove is substituted for that of stable dung. The leaden plates are exposed in this process to the united vapors of vinegar and carbonic acid gas in deal boxes, the bottoms of which are made secure from leakage by varnish, or some resinous liquid. The leaves of lead are about the thickness of the twelfth of an inch, arranged in a zigzag form upon lath, supported by a stronger piece of wood placed across the interior of the box. The leaves are isolated from each other, and distant from the surface of the vinegar about 3 inches.

To produce the carbonic acid, the union of which is requisite in making white lead, a certain proportion of the lees of wine, or tartaric acid, is added to the vinegar. The boxes are then closed, and placed upon a square tube containing warm air. This is carried around the workshop, and brings the temperature up to 100° Fahr., but must not go beyond this point, otherwise the vinegar would evaporate too rapidly, and much of it would be lost. In about fifteen days the boxes may be opened, and if the process has been well conducted, a quantity of carbonate should be collected equal to the quantity of metal employed.

1407. *Austrian method.*—The mode of making the white is quite different in this process from what it is in the methods just described. The ceruse is prepared very quickly, by forming a precipitate, with carbonic gas, in a supersaturated solution of protoxyde of lead. This solution is prepared by agitating, in a cold state, litharge and distilled vinegar; when this mixture is sufficiently concentrated, it is passed through a current of carbonic acid gas, which unites with the greater portion of the dissolved oxyde of lead; the precipitate is collected, washed carefully, and then dried for use.

1408. *Carbonate of bismuth.*—Add an alkaline carbonate to the nitrate of the metal. It is a white powder.

1409. *Carbonates of mercury.*—When the carbonate of potass is added to the protonitrate of mercury, a yellow *protocarbonate* of mercury is thrown down. If added to the pernitrate the precipitate will be the red *percarbonate.*

1410. *Carbonate of silver.*—Obtained in like manner. It is of a white color, which changes darker upon exposure to the air.

BORATES.

These salts are comparatively little known or valued, except that of soda. Those with alkaline bases are soluble, but the metallic borates insoluble, as are also those of the earths. They may be formed by adding boracic acid to a solution of the base. They are decomposed by the addition of the more violent acids.

1411. *Borate of potass.*—Boil boracic acid in a solution of potassa. This salt is not used.

1412. *Borate of soda, borax, tincal, chrysocolla.*—Combine boracic acid with soda by boiling. It is a white crystallizable salt, much used as a flux, and soluble in 12 parts of cold and 2 of hot water. The impure salt is brought here from India in vast quantities. This is a supersalt, containing a great excess of base; to render it neutral, boracic acid must be added, until it ceases to render the solution of turmeric brown.

1413. *To render clothing incombustible.*—Dissolve borax in hot water, soak the clothing in the liquid, and afterwards let it dry. It will now be impossible to inflame it, although it will burn away with a slow combustion. Alum has been recommended for the same purpose, but is more injurious to the clothing. The carbonate of potass may also be used, but is apt to contract moisture from the air, and thus render the clothes damp.

1414. *Borate of lime.*—Dissolve borax in lime water.

1415. *Borate of baryta.*—Add borax to a solution of a salt of baryta, such as the nitrate. It is greyish white, tasteless, poisonous, and insoluble.

1416. *Borate of strontia* obtained in like manner. This is white, slightly soluble, and not poisonous.

1417. *Borate of magnesia.*—Boil boracic acid in magnesia water, or else throw magnesia, a small quantity at a time into a solution of boracic acid. If the acid be in excess, the salt will be soluble and crystallize upon the solution getting cold; if the acid be neutralized, it will be insoluble, and being thrown down very similar in appearance to the magnesia used, it is very likely to be taken for it; and the operation stopped under the impression that magnesia alone was falling. Bergman was deceived by this appearance.

1418. *Borate of manganese.*—Mix a solution of borate of soda, with protosulphate of manganese.

1419. *Borates of iron.*—A protoborate or a perborate of iron is formed by adding borate of soda to the protosulphate or persulphate of the metal. The former is a yellow insoluble powder.

1420. *Borates of zinc, tin, cobalt, nickel, lead, bismuth, mercury and silver,* are obtained in like manner, using either the sulphates or nitrates of the metals. They are all insoluble, and except three are of a white color. Borate of cobalt is pink, those of nickel and copper green.

The salts we have hitherto considered are unions of one metal with two unmetallic bodies, oxygen being in most cases one of them; those ternary salts which remain to be described are such as contain two metals, that is which unite with the metallic acids, the arsenic, chromic, &c. Some of these are of the greatest value in the arts, on account of their fine and varied colors. The symbolic composition of a few of them will be given, from which the symbols of the rest will be easily determined. There are some salts of this description of which we have said little respecting their chief base, or have totally omitted an account even of the acid, such as the vanadiates, the tunstengates, &c. This has been done because such are of little value or interest, and the same intention will somewhat condense this division of the salts; nothing important however is disregarded.

MANGANATES, MANGANESIC SALTS.

Manganesite of potass. See *Ex.* 839 and 840.

1421. This curious salt from the changes it undergoes under common circumstances of solution, evaporation, &c., is often called the *chameleon mineral.* It is of a light *green* color, but when 10 or 12 grains are reduced to powder, and put into a tall jar, and a *little* water added, it will become of a *deep green.* Pouring in more water, it will alter to a *lighter green,* then blue, afterwards *purple,* and finally of a fine *red.* These changes arise from the salt attracting oxygen from the water, its acid therefore becomes the manganesic instead of the manganeseous, and as this is of a red color, it imparts that to the solution. The manganesate of potass is obtained by evaporation and crystallization. Combination with other bodies readily yielding oxygen have the same effect. Brande does not admit a manganeseous acid, he therefore calls this manganesite, a manganesate, and the latter a permanganesate.

1422. Add concentrated sulphuric acid to manganesate of potass, so that the latter shall be rendered by it into the state of a thin paste. It will give a beautiful purple vapor, which if the experiment be performed in a long glass tube, will condense in the upper part of the tube in red streaks.

1423. *Manganesate of soda.*—Procured as the manganesate of potass. No other manganesates have been examined, and even the above are soon decomposed by exposure to the air.

ANTIMONIATES.

1424. *Antimoniate of potass.*—Make some metallic antimony red hot in a crucible, and throw nitre upon it, a small portion only at a time. Take the residue, and pour upon it hot water—this will dissolve an antimoniate of potass, which may be separated by filtration, and evaporating the filtered liquor. Several metallic antimoniates may be formed by adding the above solution to solutions of the metallic salts.

ARSENITES AND ARSENIATES.

1425. *Arsenite of potass.* ($\text{Pot}+\text{Ar}''$.)—Boil arsenious acid in water with an equal weight of carbonate of potass. This is the active ingredient in *liquor arsenicalis,* and in *Fowler's arsenical solution.* The arsenite of potass does not crystallize, and is decomposed by most other acids. It is very soluble.

1426. *Arsenites of soda, lime, baryta, and magnesia,* are procured in the same way. They are all, except the first, difficultly soluble in water.

1427. *Arsenite of manganese.*—Add the arsenite of potass to the sulphate, phospate, or carbonate of manganese, a white arsenite of the metal will be deposited.

1428. *Arsenite of copper. Scheele's green.*—This beautiful green pigment is deposited upon adding the arsenite of potass to a solution of sulphate of copper.

1429. *Arsenites of zinc, tin, lead, antimony, and bismuth,* are all of a white color, and procured by adding an alkaline arsenite to a solution of any of the ordinary salts of these metals.

1430. *Arsenite of cobalt, iron and silver.*—Add the arsenite of potass to the nitrates of these metals. The arsenite of cobalt is of a fine pink color; that of silver, at first white, but afterwards yellow, and finally brown; that of iron of a dull green.

1431. *Arseniate of potass.* ($\mathrm{Pot} + \mathrm{Ar}'$.)—Add arsenic acid to potass, and boil them together, taking care that the acid be not in excess, otherwise the result is a biarseniate. The latter upon evaporation of the liquid will crystallize in quadrangular crystals, the former is uncrystallizable; hence the two salts, even if formed together, may be easily separated from each other. Of course both are soluble in water. The former is deliquescent.

1432. Add a little *arseniate* of potass to syrup of violets diluted, it will turn it of a *green* color, but added to the tincture of litmus, the latter remains unchanged. This is very singular, as the salt thus shows itself alkaline in the former part of the experiment, and neutral in the other part.

1433. Add a little *biarseniate* of potass to the same vegetable solutions; it will not have any effect upon the syrup of violets, and yet change the tincture of litmus red. Thus in the former case its want of action upon the violet solution shows it to be neutral, while added to litmus it is seen to be acid. These two experiments are sure tests of the biarseniate and arseniate of potass, the one from the other. The biarseniate is often called *Macquer's neutral arsenical salt.*

1434. *Arseniate of soda.*—Add arsenic acid to carbonate of soda, till the latter is saturated. This salt is crystallizable in rhombic prisms, and efflorescent in the air, from which it is known from the similar salt of potass. It is soluble in ten times its weight of cold water, and being then added to syrup of violets and litmus water, it shows with the former alkaline properties, with the latter no change takes place.

1435. *Biarseniate of soda.*—Add arsenic acid to the above, until it no longer precipitates the chloride of barium. The biarseniate of soda will be held in solution. This salt is deliquescent, from which it may be known from the last.

1436. *Arseniate of lime.*—Add arsenic acid to lime water, the arseniate will fall as a white powder. But it must be observed, that it only falls at the exact time of the complete saturation of the lime and the acid, for it is soluble when either the lime or the acid is in excess. It is insoluble in water.

1437. The arseniate of lime may also be made by adding arseniate of potass to nitrate of lime; or by heating together in a crucible equal parts of white arsenic (arsenious acid) and quick-lime. In this last method, a very singular effect will be observed. When the heat has increased so that the bodies act chemically upon each other, a sudden combustion takes place, and metallic arsenic sublimes; so that a part of the arsenious acid is decomposed, its oxygen uniting with the rest of the acid converts it into arsenic acid, which then combining with the lime, forms the arseniate. Other arseniates may be formed in the same manner.

1438. *Arseniate of baryta.* ($\mathrm{B} + \mathrm{Ar}'$.)—Add arsenic acid to baryta water, or else add the arseniate of soda to a solution of the chloride of barium. It is better to make the earthy and metallic arseniates by double decomposition, because they are with the exception of two or three, very soluble in excess of arsenic acid. Thus, if made by adding arsenic acid to a diffusion of the metal or its oxyde in water, the experiment although successful, may not be apparently so, because of an undue quantity of acid having dissolved what should have been a precipitate, besides which it becomes a biarseniate. ($\mathrm{B} + \mathrm{Ar}'2$.) The arseniate of baryta is a gritty white powder, insoluble in water. The first method here given is also defective, because if there be not a sufficiency of the acid, a subsesqui-arseniate ($1\frac{1}{2}\,\mathrm{B} + \mathrm{Ar}'$.) is formed. Thus merely on account of difference of quantity of materials, three different salts are obtained. The same remark applies to lime, lead, zinc, magnesia, and numerous other arsenical salts.

1439. *Arseniate of strontia.*—Add arseniate of soda to the nitrate of strontia. The arseniate of strontia will be formed, but no immediate effect will be seen to take place; yet after 24 hours, minute rectangular four-sided prisms will subside in the liquor. These constitute the salt required, they are tasteless, and somewhat soluble in water.

1440. *Arseniate of magnesia.*—Add a dilute solution of arseniate of soda to a dilute solution of sulphate of magnesia. Suffer the mixture to rest for 24 hours; a confused mass of crystals and white grains of the arseniate of magnesia are deposited. These are in a very slight degree soluble in water, but very soluble if the acid be in excess. It is then of course the biarseniate as before observed.

1441. *Arseniate of manganese.*—Add arseniate of potass or of soda to the chloride of manganese. It is a white insoluble powder.

1442. *Arseniate of iron.*—Add arseniate of ammonia (made by adding arsenic acid to liquid ammonia) to a sulphate of iron; if the protosulphate be employed, the result will be a protoarseniate; if a persulphate, a perarseniate. They are both white powders, but the former becomes green when exposed to the air. They are also insoluble in water, but soluble in ammonia, forming then *subsalts.*

1443. *Arseniate of zinc.*—Add an alkaline arseniate to a solution of sulphate of zinc. The resulting arseniate is white, gelatinous, and insoluble in water.

1444. *Arseniate of tin.*—Add an alkaline arseniate to a solution of the protochloride of the metal. It precipitates and is of a white color.

1445. *Arseniate of cobalt.*—This salt is to be made by adding arsenic acid to the *ammonio-chloride* of cobalt, as follows:—First dissolve the chloride of cobalt in a small quantity of water, then add chloride of ammonia equal in weight to the chloride employed; this forms the ammonia chloride of cobalt. To this the strong acid is to be added, when after a time the arseniate of cobalt will be precipitated in the state of an insoluble rose-colored powder. The chloride of ammonia remains in solution. The arsenic acid has no effect upon either the chloride or the acetate of cobalt, except at a red heat, therefore putting equal parts of arsenic acid and chloride, or acetate of cobalt together in a crucible, the hydrochloric or acetic acid is driven off, and the cobalt and arsenic acid uniting form the arseniate. In this manner most arseniates may be formed from the nitrates of the metals.

1446. When arseniate of soda is added to sulphate of cobalt, an arseniate of the metal is formed of a dirty red color.

1447. *Arseniate of nickel,* made as the arseniate of zinc. It is of an apple green color.

1448. *Arseniate of copper,* made as the arseniate of zinc. The result is a bluish green precipitate.

1449. *Arseniate of lead.*—Add arseniate of soda to a solution of the nitrate of lead. If more of the alkaline arseniate be used than suffices to neutralize the nitrate, a *subarseniate* of the metal is formed.

1450. *Arseniates of antimony.*—Use arseniate of potass and chloride of antimony.

1451. *Arseniate of bismuth.*—Use arsenic acid to a solution of the nitrate of bismuth. This differs from most of the other metallic arseniates in not being soluble in excess of the acid, therefore in its preparation we need not have recourse to double decomposition, nor need we fear using a trifling excess of the arsenic acid, as this would be held in watery solution, while the arseniate would fall down.

1452. *Arseniate of silver.*—Add arseniate of potass to a solution of the nitrate of silver. The arseniate of the metal will be thrown down as an insoluble powder of a *brick red* color.

1453. *Arseniates of mercury.*—These not being soluble in arsenic acid, may, like that of bismuth, be made by the direct action of the acid upon a salt of mercury. If a protosalt be used, the result will be a protoarseniate of mercury, which is of a pale yellow color; if a persalt, as for example, the pernitrate, a dirty white perarseniate will be produced.

1454. *Arseniate of alumina.*—Mix the powders of arsenious acid and alumina in a crucible, and submit them to a red heat, or else mix the two together in solution. The salt does not crystallize, and is insoluble in water. Arsenic acid heated in earthenware crucibles, retorts, &c., soon corrodes them by its action on the alumina of the vessels.

CHROMATES, OR CHROMES.

Of all salts the chromates present the greatest variety and the most beautiful colors, crimson, chocolate, red, green, yellow, orange of the most vivid tints are amongst them, even the salts of the alkali potass are brilliantly colored, though those made with other acids are colorless or white. These circumstances render the chromates of extensive use to the painter, and also to the chemist—to the former as pigments, to the latter as tests; the chromate of potass, the most convenient of these salts precipitating the majority of the metals from their solutions, each with its own marked characteristic. The chromates are mostly insoluble in water.

Ex. 1455. *Chromate of potass.* (Chr′ + Pot.)—This valuable salt, by the aid of which most of the other chromates are to be procured, crystallizes of a beautiful yellow color, the crystals being soluble in about twice their weight of boiling water. It may be procured as follows from the chromate of iron, a somewhat abundant mineral. The ore is reduced to a fine powder, by being ground in a mill under ponderous edgewheels and sifted. It is then mixed with $\frac{1}{8}$ or $\frac{1}{2}$ its weight of coarsely bruised nitre, and exposed to a powerful heat for several hours, being stirred about occasionally. The calcined matter is then raked out and lixiviated with water. The bright yellow solution is then evaporated briskly, and the chromate of potass falls down in the form of a granular salt, which may be crystallized by redissolving and slowly evaporating.

1456. *Bichromate of potass.*—This beautiful red salt is obtained by adding sulphuric acid, nitric acid, or other strong acid, to a solution of the chromate, until it tastes sour; it is then set aside for a day or two, when crystals of the bichromate will be formed. This salt is much employed in calico printing and dyeing.

1457. *Chromate of soda*, and *bichromate of soda.*—The first of these is *yellow*, the latter *red*, and both procured in the same manner as the corresponding salts of potass, using in the first instance the nitrate of soda, instead of saltpetre.

1458. *Chromate of lime.*—Add chromate of potass to a solution of chloride of lime, a *yellow* chromate of lime gradually falls as a fine powder.

1459. *Chromate of baryta*, procured in the same manner as the chromate of lime; and very much like it in appearance, except that it is of a paler color.

1460. *Chromate of strontia.*—This is also pale yellow, and procured in like manner.

1461. *Chromate of manganese.*—Neither chromate nor bichromate of potass produce any immediate precipitate with solutions of the protoxyde of manganese, but after a time a *brown* precipitate falls.

1462. *Chromate of iron.*—This is a natural production, but may be made artificially by adding chromate of potass to a solution of the sulphate of the peroxyde of iron. This is a soluble salt.

1463. *Chromate of zinc.*—Add chromate of potass to sulphate of zinc. This precipitate is yellow and very abundant.

1464. *Chromate of tin* is yellow and insoluble; *chromate of cobalt* grey and insoluble; *chromate of nickel* red and deliquescent; and *chromate of copper* buff-colored and insoluble; or if the nitrate be used, it will be chesnut-red. These are procured in the same manner as the chromate of zinc.

1465. *Subchromate of nickel.*—Add potass or soda to the chromate of nickel, a subchromate will be deposited of a beautiful orange tint.

1466. *Chromate of lead, chrome yellow.*—This is a rich pigment of various shades, from deep orange to the palest canary yellow. It is made by adding a limpid solution of the neutral chromate of potass to a solution equally limpid of acetate or nitrate of lead. A precipitate falls, which must be well-washed and carefully kept out of the reach of sulphuretted vapors. A light shade of yellow is obtained by mixing some solution of alum or sulphuric acid with the chromate, before mixing it with the solution of lead, and an orange tint is to be procured by the addition of subacetate of lead in any desired proportion.

1467. *Subchromate of lead, chrome red.*—Into saltpetre brought to fusion, in a crucible at a gentle heat, pure chrome yellow is to be thrown by small portions at a time. A strong ebullition takes place at each addition, and the mass becomes black, and continues so while hot. The chrome yellow is to be added till little of the saltpetre remains undecomposed, care being taken not to overheat the crucible, lest the color of the mixture should become brown. Having allowed it to settle for a few minutes, during which the dense basic salt falls to the bottom, the fluid part, consisting of chromate of potass and saltpetre, is to be poured off, and it can be employed again in preparing chrome yellow. The mass remaining in the crucible is to be washed with water, and the chrome red being separated from the other matters is to be dried after proper washing. It is essential for the beauty of the color, that the saline solution should not stand long over the red powder, because the color is thus apt to become of a dull orange hue.

1468. A second method of preparing this red subchromate, is by boiling the chromate with two-thirds its weight of oxyde of lead in water.

1469. *Chromate of antimony.*—Add chromate of potass to chloride of antimony, the chromate will be decomposed, and that of antimony formed; but as this is soluble in excess of the solution of the chloride, the only effect at first perceptible, is that the mixed solutions assume a green color, though afterwards, a *brown* precipitate is thrown down.

1470. *Chromate of bismuth.*—Mix the alkaline chromate with nitrate of bismuth in solution. The precipitate is of a pale yellow, partially soluble in water.

1471. *Chromate of mercury*, prepared in like manner, is of an *orange* color; but when chromic acid is added to a solution of the nitrate of mercury, the precipitate is chocolate red.

1472. *Chromate of silver* prepared in like manner, using the nitrate of silver. When fresh deposited, it is of the finest possible crimson color, but afterwards by exposure to the air, it becomes *purple* and then brown.

1473. If the chromate of silver be exposed to a strong heat, it melts and assumes a blackish appearance. If it be then pulverized, the powder becomes purple again, but if it be again heated, it assumes a *green* color, while metallic silver is deposited, and appears in globules disseminated through its substance.

1474. *Chromate of gold.*—Add chromate of potass to chloride of gold, the precipitate will be greenish.

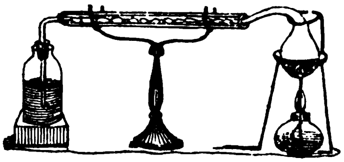
1475. *Chromate of platinum* procured in like manner, is of a lemon yellow.

1476. *To make the chromates generally.*—Take 1 part of bichromate of potass, and 4 of strong sulphuric acid; mix and digest at a moderate temperature for some hours, oxygen is given off, sulphate of chromium and sulphate of potass remain. To separate these is now the great object; to effect this, neutralize the mixture with powdered chalk or marble, and then add carbonate of soda or potass till no more precipitate falls, then wash and dry the precipitate. This precipitate, which consists of carbonate of chromium, may be converted into sulphate. chloride, &c., by mere solution in the acid.

THE CYANIDES.

Ex. 1477. ***Prussic acid, hydrocyanic acid.*** ($Cy + H$.)—This occurs in the kernels of most stone fruits, the peach, plum, and almond, and also in the leaves of the laurel and some other trees. It is known at once by that peculiar taste and smell which the kernels of these stone fruits have when bruised. The quantity which exists in these substances however, is not sufficient to render them poisonous, unless we eat or drink more than we would choose to do. The acid in its pure state is extremely volatile, so that there is almost equal danger in smelling a phial of the acid, as in taking a small quantity of the contents. Its action upon the system is immediately to paralyze the nerves, and thereby to occasion death as rapidly; no pain however attends its exhibition, as it does not kill by corroding the coats of the stomach, as is the case with the acrid poisons. Its volatility however is so great, that if it do not occasion death within a few minutes, it does not act at all, but is entirely evaporated. Its antidote is ammonia, though sudden and violent effusion of cold water over the head and back is considered preferable. Cyanogen and hydrogen have no direct mutual action, but by the action of certain acids on the metallic cyanurets, hydrocyanic acid is formed by double decomposition. The following are various approved processes:—

1478. Vauquelin's process for preparing the strong acid consists in transmitting a stream of hydrosulphuric acid slowly over the bicyanide of mercury, heated gently in a tube (which may be about 18 inches long, and at least half an inch in diameter internally,) nearly filled with this substance, and placed horizontally, in the manner represented in the figure. The hydrosulphuric acid is passed over it till the whole of the bicyanide has become black, none of this gas escaping through the other extremity of the tube till all the bicyanide is decomposed; and whenever the odour of hydrocyanic acid is perceived at the mouth of the receiver, the tube A, connected with the apparatus in which the gas is produced, is withdrawn, and the extremity of the other tube into which it was previously inserted is closed with a little plaster of Paris, or with a glass-stopper luted tightly to it. It is heated gently when the lute has set, and the hydrocyanic acid which has been formed, is volatilized and condensed in a small receiver placed in a freezing mixture.



1479. The hydrocyanic acid obtained in this manner is very strong and pure, and equal in weight, when carefully collected, to about a fifth part of the bicyanide employed.

1480. There is another method of preparing this acid in a concentrated state. Pour 9 parts by weight of hydrochloric acid, specific gravity 1.15, on 10 of the bicyanide of mercury in a small glass-retort, the beak of which is connected with a receiver or tube in the manner represented in the last figure, the tube being filled with fragments of marble and chloride of calcium. A reaction takes place between the bicyanide of mercury and the hydrochloric acid (which is composed of chlorine and hydrogen), the chlorine, in two equivalents of the acid, combining with the mercury in one equivalent of the bicyanide, and forming bichloride of mercury, while the corresponding equivalents of hydrogen and cyanogen unite and produce two of hydrocyanic acid. The hydrocyanic acid is always mixed at first with a little water and hydrochloric acid; the tube in which it condenses should be kept cold. On removing the retort and closing the extremity of the tube, it passes over into the receiver when a gentle heat is applied, the chloride of calcium retaining the water, and the marble the hydrochloric acid. A slight excess of the bicyanide is employed to prevent as much as possible the escape of any hydrochloric acid.

1481. Concentrated hydrocyanic acid is speedily decomposed by the reaction of its elements, and a diluted acid is employed for most chemical and all medical purposes. In

No. 14 of the "Glasgow Medical Journal." The following is his formula:—

Tartaric acid	72 grains.
Cyanide of potassium	32 grains.
Distilled water	1 ounce.

In an ounce phial, furnished with a cork or stopper, which should, by previous examination, be ascertained to be sufficient, dissolve the tartaric acid in the water. Then add the cyanide of potassium, and immediately after insert the cork or stopper, which for a little time must be preserved firmly in its situation [illegible] the finger. Meanwhile agitate, keeping the phial immersed in a basin of cold water, in order to repress the heat produced in the process. When all action has ceased, set the [illegible] aside in a cool and dark place for twelve [illegible] in order that the cream of tartar [illegible] may subside. Afterwards decant the [illegible] which preserve in a cool and dark [illegible]

An ounce of water dissolves no more than [illegible] grains of cream of tartar, and its [illegible] power is likely to be diminished by the presence of hydrocyanic acid; therefore, [illegible] the cream of tartar formed, except 5 [illegible] that is 86 grains, will subside; and the water will hold in solution, besides these [illegible] of cream of tartar, 13 grains of [illegible] acid. But this solution will [illegible] about 26 full doses (we will say 25) [illegible] hydrocyanic acid. Of cream of tartar, [illegible] each dose will contain only $\frac{5}{25}$, or [illegible]

[illegible] *Cyanide of potassium.*—The ferrocyanate of potass or Prussian blue, is regarded as a compound of the cyanide of potassium, the [illegible] of iron and water. By exposing [illegible] heat in an iron bottle as long as [illegible] disengaged, after expelling water [illegible] heat, all the cyanide of iron is [illegible] but none of the cyanide of potassium [illegible] must be taken to exclude the [illegible] air, otherwise the cyanide of [illegible] will also be decomposed. On [illegible] the residuum with water and filtering, [illegible] obtained, which gives crystals [illegible] cyanide of potassium upon evaporation. [illegible] cyanide of soda is procured in the [illegible]

[illegible] *Bicyanide of mercury* is prepared by boiling [illegible] parts of purified Prussian blue, [illegible] of the peroxide (binoxide) of mercury, and [illegible] of water, in an earthen evaporating basin, reducing both to a fine powder previously and continuing the heat for ten or fifteen minutes. The Prussian blue consists of iron, cyanogen, oxygen, and hydrogen, and is obtained sufficiently pure for this purpose by digesting the Prussian blue of commerce in hydrochloric acid diluted with ten times its bulk of water, which removes the alumina and other foreign matters it usually contains, washing it repeatedly with water till the excess of acid has been removed. In this process, each equivalent of peroxide of mercury acquires two equivalents of hydrocyanic acid from the Prussian blue, and is converted into biperhydrocyanate of mercury. The biperhydrocyanate remaining in solution is separated by filtration, and on evaporating the liquid till a pellicle appears on its surface, crystals of the bicyanide of mercury are obtained when it cools; the two equivalents of hydrogen in the two of hydrocyanic acid, uniting with the oxygen of the peroxide, while the cyanogen goes to the metallic mercury.

1487. *Second method.*—Another process for the preparation of the bicyanide of mercury consists in adding the peroxide of mercury finely pounded in minute successive portions to hydrocyanic acid diluted with 20 parts of water. The same changes take place between the peroxide and the hydrocyanic acid which have already been explained. In conducting this process, the mixture must be repeatedly agitated, and afterwards heated. Strong hydrocyanic acid must not be employed, as when it comes in contact with the peroxide of mercury in a minute state of division, considerable heat is produced, and it might be converted rapidly into vapor with great danger to the operator. In heating and concentrating the solution, also, unless all excess of the acid be combined with the peroxide previously, the fumes that escape must be carried off carefully at a ventilator.

1488. *Cyanide of silver.*—Add a solution of hydrocyanate (prussiate) of potass to a solution of nitrate of silver. The precipitate of the cyanide of silver must be dried very carefully, for if too much or too rapid a heat be applied, detonation is apt to take place from its rapid decomposition.

1489. *Cyanide of chlorine, oxyprussic acid, chlorocyanic acid.*—When chlorine is transmitted through diluted hydrocyanic acid till it has acquired the property of decolorizing a solution of indigo in sulphuric acid, one portion of the chlorine combines with the cyanogen of the acid, forming cyanide of chlorine, and another with the hydrogen, forming hydrochloric acid. The excess of chlorine may be removed by agitating the liquid with mercury, and on exposing it to heat, the cyanide of chlorine is disengaged in the gaseous form, and must be collected over the mercurial trough, as it is soluble in water. Cyanide of chlorine was formerly termed chlorocyanic acid, but it was found to possess no acid properties on more minute examination. It has a very pungent and irritating smell, and is absorbed rapidly by solutions of the alkalis, alcohol, and water. When cooled by a freezing mixture, it becomes liquid at 10°, and freezes at zero.

1490. *Cyanide of iodine* is prepared by exposing the bicyanide of mercury mixed intimately with half its weight of iodine to heat in a small glass-retort; vapors of iodine are disengaged at first, and these are soon followed by white fumes of the cyanide of iodine, having the appearance of wool, which may be condensed in a cold receiver in the solid form.

1491. *Cyanide of bromine* is prepared by a similar process, and bears a great resemblance to the cyanide of iodine. It appears to be as powerful a poison as the hydrocyanic acid.

1492. *Cyanide of sulphur.*—Sir H. Davy obtained this compound in 1816, by heating a mixture of sulphur and bicyanuret of mercury. It is a yellow substance.

1493. *Cyanide of barium.*—Mix hydrocyanic acid with baryta water.

1494. *Cyanide of manganese.*—Add a solution of cyanide of potassium to the solution of any protosalt of manganese. When the cyanide of potassium is in excess, the newly-formed cyanide is dissolved, and afterwards crystallizes in *brown* needle-shaped crystals.

1495. *Cyanide of calcium.*—This salt cannot be obtained in a dry crystallized form, but a solution of it is formed when slaked lime is digested in hydrocyanic acid. Upon attempting to dry the solution by evaporation, it is decomposed into ammonia and carbonate of lime.

1496. *Protocyanuret of iron, protocyanide of iron, ferrocyanogen.*—This is difficult to procure or to keep, as it rapidly absorbs oxygen, and becomes thereby converted into Prussian blue, which is now called the ferrosesquicyanuret of iron, and will be described under the ferrocyanurets in the next chapter, they being double salts, and containing four elements. The protocyanuret of iron is formed by adding a pure protosalt of iron, to a solution of the cyanide of potassium. It consists of iron 1, carbon 2, nitrogen 1 atom.

1497. *Cyanide of zinc.*—Add a solution of cyanide of calcium to sulphate of zinc. It is a white insoluble powder, which when strongly heated and for a length of time, becomes decomposed, and leaves a black carburet of zinc.

1498. *Cyanides of cobalt, lead,* and *nickel.*—Add hydrocyanic acid to the acetate of the metals.

1499. *Cyanide of gold.*—Add cyanide of potassium to a solution of chloride of gold. It is an insoluble pale yellow compound.

TERNARY ACIDS.

These being all of vegetable origin are usually called the vegetable acids, and are for the most part procurable by the simple process of expressing the juice of those plants which contain them, or else by their fermentation. These acids are generally milder in character, and less energetic in their chemical relations than the mineral acids. Their constituent principles are oxygen, hydrogen, and carbon, differently combined.

*Ex.*1500. *Tartaric acid.* $(C4 + H2 + O5)$—This acid may be obtained in a pure state by pressing the juice from unripe grapes, or vine leaves and tendrils; also by the expression of the juice from tamarinds. It is however most usually prepared from the *tartar* or tartrate of potass, deposited in wine, by the following processes:—

1501. *Second method.*—Mix 100 parts of the tartar in fine powder with 30 of powdered chalk, and gradually throw the mixture into 10 times its weight of boiling water; when the liquor has cooled, pour the whole upon a linen strainer, and wash the white powder which remains with cold water; this is the tartrate of lime. Diffuse this in water, and add sulphuric acid equal in weight to the chalk employed, and occasionally stir the mixture during 24 hours; then filter and carefully evaporate the liquor to about ¼ of its original bulk; filter again and evaporate with much care nearly to dryness; redissolve the dry mass in about 6 times its weight of water, render it clear by filtration, evaporate slowly to the consistency of syrup, and set aside in a warm place to crystallize. By two or three successive solutions and crystallizations, tartaric acid will be obtained in nearly colorless crystals; they may be perfectly whitened by the aid of a little animal charcoal.

1502. *Decomposition of.*—Boil tartaric acid and nitric acid together; the former is partly converted into oxalic acid by absorbing oxygen from the nitric acid. Boil it with sulphuric acid, and it will be changed into the acetic acid; in this case losing oxygen. It is also decomposed into acetic acid by a red heat, or by fusing it with caustic potass into the oxalic. Tartaric acid is used in calico printing, as a substitute for citric acid in effervescing mixtures, and as a test for the salts of potass, &c. Its salts are called tartrates.

1503. *Oxalic acid.* $(C2 + H1 + O4 = 45.)$—This acid is found in the stems of rhubarb, the leaves of sorrel and of wood sorrel, and in some fruits. It is most easily procured by the action of nitric acid upon certain organic substances, and especially upon sugar, and hence it has been termed *acid of sugar.* It may be obtained by introducing into a retort, 4 ounces of nitric acid diluted with 2 of water, and 1 ounce of white sugar; nitric oxyde gas is copiously evolved, and when the sugar is dissolved, about one-third of the acid may be distilled over; the contents of the retort are then emptied into a shallow vessel, and in the course of two or three days an abundant crop of white crystals is deposited, and upon further evaporation of the mother liquor a second portion is obtained. The whole crystalline portion is to be redissolved in water, and again crystallized, by which the pure acid is obtained. In this way sugar yields rather more than half its weight of oxalic acid. This acid is highly poisonous, and has much the appearance of Epsom salts.

1504. *Intensity of the acid.*—Put 1 grain of oxalic acid into 3 gallons of water, and dip a piece of litmus paper into the solution; such is the intensity of the acid, that even thus diluted, it will change the litmus to a red color.

1505. *Decomposition of.*—This like most of the vegetable acids is decomposed by heat; even raised to a temperature of 300°, it becomes converted into water, carbonic acid, carbonic oxyde, and formic acid.

1506. *Cleaning boot-tops and brown leather harness, &c.*—Dissolve oxalic acid in water, in the proportion of an ounce to ½ a pint of water; apply it to the leather with a sponge.

1507. *Citric acid.* $(C4 + H3 + O5 = 67.)$—"This acid causes the sourness of lemons, limes, and oranges. It is also, but combined with malic acid, to be obtained from many other fruits such as gooseberries, currants, and raspberries. It is obtained from lemon juice as follows:—Boil the expressed juice for a few minutes, and when cold, strain it through fine linen; then add powdered chalk as long as it produces effervescence, heat the mixture and strain as before, a quantity of citrate of lime remains upon the strainer, which having been washed with cold water, is to be put into a mixture of sulphuric acid, with 20 parts of water, the proportion of acid may be about equal to that of the chalk employed. In the course of 24 hours the citrate of lime will have suffered decomposition, and sulphate of lime is formed, which is separated by filtration. The filtered liquor by careful evaporation furnishes crystallized citric acid. In flavor this acid is very agreeable. The average proportion of citric acid furnished by a gallon of good lemon juice is about 8 ounces. The crystals are soluble in about their weight of cold water, and half their weight of boiling, and differ in a slight degree according to the manner in which they have been obtained."—*Magazine of Science.*

1508. *To procure citric acid from gooseberries.*—The expressed juice is fermented and then distilled; this separates the alcohol and acetic acid, the residue is saturated by chalk, and the washed citrate of lime decomposed by sulphuric acid; 100 parts of gooseberry juice do not afford more than 1 of acid.

1509. *Malic acid, sorbic acid.* ($C_4 + H_2 O_4 = 58$,) is present in the juice of apples, in the berries of the mountain ash, and hawthorn, and in the leaves of the house-leek. Express the juice of ripe apples, and add to it acetate of lead, by this the acetate will be decomposed, and a malate be formed. This is afterwards to be decomposed by sulphuric acid, as recommended for citric acid. Malic acid can scarcely be obtained in a crystallized form, it is therefore known chiefly in solution.

1510. *Formic acid.* ($C_2 + H + O_3 = 37$.)—This acid was once considered a peculiar formation in the bodies of ants, hence its name. It was shown afterwards to be capable of production from the peroxydizement of various vegetable substances, and that consequently it may be obtained by chemical means. The following method is one among numerous others for its production. Mix together 2 parts of crystallized tartaric acid, 5 of peroxyde of manganese, 5 of sulphuric acid, and 5 of water. Soon after mixture, these ingredients which should be in a sufficiently capacious retort, effervesce violently, and give off abundance of carbonic acid; if afterwards distilled, the formic acid passes over, and may be concentrated in vacuo. It is a sour, colorless liquid. Its salts are *formiates*. They and also the acid itself is of little use.

1511. *Acetic acid.* ($C_4 + H_3 + O_3 = 51$,) is the name of the sour principle which exists in vinegar. It occurs, ready formed, in several products of the vegetable kingdom, and is generated during the spontaneous fermentation of many vegetable and animal juices. The *sambucus nigra*, or black elder, the *phœnix dactilifera*, and the *rhus typhinus* are plants which afford a notable quantity of vinegar. It is found, likewise, in the sweat, urine, milk, and stomach of animals. All infusions of animal or vegetable matters in water, when exposed for some time to the air, at a moderate temperature, ferment into vinegar; and most vegetables, when subjected to decomposition by fire, give off condensable vapors of acetic acid. All liquids containing alcohol are susceptible of passing into a state of vinegar; but the pre-existence of alcohol is not necessary to this change, as we learn from the acetification of vegetable soups, infusion of cabbage, starch, paste, &c. Vinegar may be distinguished into four varieties, according to the mode of its production, though all of them are capable of being converted, by chemical means, into one identical acetic acid. 1. Wine vinegar. 2. Malt vinegar. 3. Sugar vinegar. 4. Wood vinegar, or pyroligenous acid. Fermentation is the source of the acid in the first three varieties. Here alcohol is first generated, and is next converted into vinegar by the influence of the air at a genial temperature. But the conversion of spirit of wine into acetic acid may be demonstrated by direct experiment. Under a large case, which for experimental purposes may be made of glass, several saucer-shaped dishes of pottery or wood are to be placed in rows, upon shelves over each other, a few inches apart. A portion of spongy platina powder moistened being suspended over each dish, let as much vinous spirits be put into them as the oxygen of the included air shall be adequate to acidify. This quantity may be inferred from the fact, that 1000 cubic inches of air can oxygenate 110 grains of absolute alcohol, converting them into 122 grains of absolute acetic acid, and 64½ grains of water. The above simple apparatus is to be set in a light place (in sunshine, if convenient,) at a temperature of from 68° to 86° Fahr., and the evaporation of the alcohol is to be promoted by hanging several leaves of porous paper in the case, with their bottom edges dipped in the spirit. In the course of a few minutes, a most interesting phenomenon will be perceived. The mutual action of the platina and the alcohol will be displayed by an increase of temperature, and a generation of acid vapors, which, condensing on the sides of the glass-case, trickle in streams to the bottom. This striking transformation continues till all the oxygen of the air be consumed. If we wish, then, to renew the process, we must open the case for a little time, and replenish it with air. With a box of 12 cubic feet in capacity, and with a provision of 7 or 8 ounces of the platina powder, we can, in the course of a day, convert 1 pound of alcohol into pure acetic acid, fit for every purpose, culinary or chemical. With from 20 to 30 pounds of the platina powder (which does not waste), we may transform, daily, nearly 300 pounds of bad spirits into the finest vinegar. Though our revenue laws preclude the adoption of this elegant process upon the manufacturing scale in this country, it may be regarded as one of the greatest triumphs of chemistry, where art has rivalled nature in one of her most mysterious operations.

1512. *To make vinegar.*—When we expose any spirituous liquors, as wine, beer, &c., with the requisite ferment, to the external air, at a temperature of from 64° to 68° Fahr., the fluid, however clear before, becomes soon turbid; filamentous slimy particles begin to appear moving in the middle and on the sides of the vessel, and then form a scum on the top of the liquor. When this scum has acquired a certain thickness and consistence, it falls in a sediment to the bottom. The Germans call it the vinegar *mother*, as it serves to excite acetification in fresh liquors. Meanwhile, the liquor has become warmer than the surrounding air, and the vinegar process betrays itself by diffusing a peculiar aroma in the apartment. Whenever all the alcohol present has been converted into acetic acid, the liquor comes into a state of repose; its temperature sinks to the pitch of the atmosphere; it becomes bright, and is the article well known by its taste and smell under the name of vinegar.

1513. *Malt vinegar.*—The greater part of British vinegar is made from malt, by the following process:—1 boll of good barley malt, properly crushed, is to be mashed with water at 160° Fahr. The first water should have that temperature; the second must be hotter than 160°, and the third water, for the extraction of all the soluble matter, may be boiling hot. Upon the whole, not more than 100 gallons of wort should be extracted. After the liquor has cooled to 75° Fahr., 3 or 4 gallons of beer yeast are poured in, and well-mixed with a proper stirrer. In 36 or 40 hours, according to the temperature of the air, and the fermenting quality of the wash, it is racked off into casks, which are laid upon their sides in the fermenting apartment of the vinegar work, which should be kept at a temperature of 70° at least; in summer partly by the heat of the sun, but in general by the agency of proper stoves. The bung-holes should be left open, and the casks should not be full, in order that the air may act over an extensive surface of the liquor.

1514. *Sugar vinegar.*—By pursuing the following plan, an excellent sugar vinegar may be made. In 158 quarts of boiling water dissolve 10 pounds of sugar, and 6 pounds of tartar; put the solution into a fermenting cask, and when it is cooled to the temperature of from 75° to 80°, add 4 quarts of beer yeast to it. Stir the mixture well, then cover the vessel loosely, and expose it for six or eight days to the vinous fermentation, at a temperature of from 70° to 75° Fahr. When it has become clear, draw off the vinous liquor, and either acidify it in the graduation tub above described, or by the common vinegar process. Before it is finished, we should add to it 12 quarts of strong spirits (brandy), and 15 quarts of good vinegar, to complete the acetous fermentation. With a graduation tub which has been used, this addition of vinegar is unnecessary.

1515. The following simpler prescription for making sugar vinegar deserves attention. For every gallon of hot water take 18 ounces of sugar; and when the syrup has cooled to 75°, add 4 per cent. by measure of yeast. When the vinous fermentation is pretty well advanced, in the course of two or three days, rack off the clear wash from the lees into a proper cask, and add 1 ounce of tartar, and 1 of crushed raisins, for every gallon of water. Expose it in a proper manner, and for a proper time, to the acetifying process; and then rack off the vinegar, and fine it upon beech chips. It should be afterwards put into bottles, which are to be well corked.

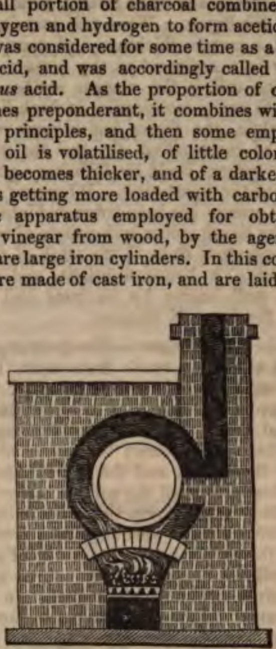
1516. *Distilled, or aromatic vinegar.*—Before the process for pyroligneous acid, or wood vinegar, was known, there was only one method of obtaining strong vinegar practised by chemists; and it is still followed by some operators, to prepare what is called radical or aromatic vinegar. This consists in decomposing, by heat alone, the crystallised binacetate of copper, commonly, but improperly, called distilled verdigris. With this view we take a stoneware retort, (see fig.) of a size suited to the quantity we wish to operate upon; and coat it with a mixture of fire clay and horsedung, to make it stand the heat better. When this coating is dry, we introduce into the retort the crystallised acetate slightly bruised, but very dry; we fill it as far as it will hold without spilling when the beak is considerably inclined. We then set it in a proper furnace. We attach to its neck an adopter pipe, and two or three globes with opposite tubulures, and at last a globe with a vertical tubulure. The apparatus is terminated by a Welter's tube, with a double branch; the shorter issues from the last globe, and the other dips into a flask filled with distilled vinegar. Every thing being thus arranged, we lute the joinings with a putty made of pipeclay and linseed oil, and cover them with glue paper. Each globe is placed in a separate basin of cold water, or the whole may be put into an oblong trough, through which a constant stream of cold water is made to flow. The tubes must be allowed a day to dry. Next day we proceed to the distillation, tempering the heat very nicely at the beginning, and increasing it by very slow degrees till we see the drops follow each other pretty rapidly from the neck of

the retort, or the end of the adopter tube. The vapors which pass over are very hot, whence a series of globes are necessary to condense them. We should renew, from time to time, the water of the basins, and keep moist pieces of cloth upon the globes; but this demands great care, especially if the fire be a little too brisk, for the vessels become in that case so hot, that they would infallibly be broken, if touched suddenly with cold water. It is always easy for us to regulate this operation, according to the emission of gas from the extremity of the apparatus. When the air bubbles succeed each other with great rapidity we must damp the fire. The liquor which passes in the first half hour is weakest; it proceeds, in some measure, from a little water sometimes left in the crystals, which when well made, however, ought to be anhydrous. A period arrives towards the middle of the process when we see the extremity of the beak of the retort, and of the adopter, covered with crystals of a lamellar or needle shape, and of a pale green tint. By degrees these crystals are carried into the condensed liquid by the acid vapors, and give a color to the product. These crystals are merely some of the cupreous salt forced over by the heat. As the process approaches its conclusion, we find more difficulty in raising the vapors; and we must then augment the intensity of the heat. As the process approaches its conclusion, we find more difficulty in raising the vapors; and we must then augment the intensity of the heat, in order to continue their disengagement. Finally, we judge that the process is altogether finished, when the globes become cold, notwithstanding the furnace is at the hottest, and when no more vapors are evolved. The fire may then be allowed to go out, and the retort to cool.

As the acid thus obtained is slightly tinged with copper, it must be rectified before bringing it into the market. For this purpose we may make use of the same apparatus, only substituting for the stoneware retort a glass one, placed in a sand bath. All the globes ought to be perfectly clean and dry. The distillation is to be conducted in the usual way. The total acid thus obtained forms nearly one-half of the weight of the acetate employed, and the residuum forms three-tenths; so that about two-tenths of the acid have been decomposed by the heat, and are lost.

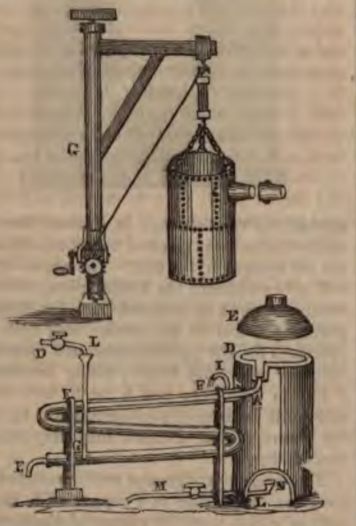
1517. *Pyroligneous acid*, or *wood vinegar*.—When we distil a vegetable body in a close vessel, we obtain at first the included water, or that of vegetation; there is next formed another portion of water, at the expense of the oxygen and hydrogen of the body; a proportional quantity of charcoal is set free, and with the successive increase of the heat a small portion of charcoal combines with the oxygen and hydrogen to form acetic acid. This was considered for some time as a peculiar acid, and was accordingly called *pyroligneous* acid. As the proportion of carbon becomes preponderant, it combines with the other principles, and then some empyreumatic oil is volatilised, of little color, but which becomes thicker, and of a darker tint, always getting more loaded with carbon.

The apparatus employed for obtaining crude vinegar from wood, by the agency of heat, are large iron cylinders. In this country they are made of cast iron, and are laid horizontally in the furnace; in France, they are made of sheet iron rivetted together, and they are set upright in the fire. The above figure will give an idea of the British plan, which is much the same as that adopted for decomposing pit coal in gas works, only that the cylinders for the pyroligneous acid manufacture are generally larger, being frequently 4 feet in diameter, and 6 or 8 feet long, and built horizontally in brickwork, so that the flame of one furnace may play around two of them.



The crude pyroligneous acid is rectified by a second distillation in a copper still, in the body of which about 20 gallons of viscid tarry matter are left from every 100. It has now become a transparent brown vinegar, having a considerably empyreumatic smell, and a sp. gr. of 1·013. Its acid powers are superior to those of the best household vinegar, in the proportion of three to two. By redistillation, saturation with quicklime, evaporation of the liquid acetate to dryness, and conversion into acetate of soda by sulphate of soda, the empyreumatic matter is so completely dissipated, that on decomposing the pure acetate of soda by sulphuric acid, a perfectly colorless and grateful vinegar rises in distillation. Its strength will be proportionable to the concentration of the decomposing acid.

1518. *French method*.—The manufacture of pyroligneous acid is conducted in the following way in France. Into large cylindrical vessels, made of rivetted sheet iron, and having at their top and side a small sheet iron cylinder, the wood intended for making charcoal is introduced. To the upper part of this vessel a cover of sheet iron is adapted, which is fixed with bolts. This vessel, thus closed, represents a vast retort. When it is prepared, it is lifted by means of a swing crane G, and placed in a furnace D, of a form relative to that of the vessel, and the opening of the furnace is covered with a dome, made of masonry or brickwork. The whole being thus arranged, heat is applied in the furnace at the bottom. The moisture of the wood is first dissipated, but by degrees the liquor ceases to be transparent, and becomes sooty. An adopter tube is then fitted to the lateral cylinder. This adopter enters into another tube at the same degree of inclination which commences the condensing apparatus. The means of condensation vary according to the localities. In certain works they cool by means of air, by making the vapor pass through a long series of cylinders, or sometimes even through a series of casks connected together; but most usually water is used for condensing, when it can be easily procured in abundance. The most simple apparatus employed for this purpose consists of two cylinders F F, the one within the other, and which leave between them a sufficient space to allow a considerable body of water to circulate along and cool the vapors. This double cylinder is adapted to the distilling vessel, and placed at a certain inclination. To the first double tube, F F, a second, and sometimes a third, entirely similar, are connected, which to save space return upon themselves in a zigzag fashion. The water is set in circulation by an ingenious means now adopted in many different manufactories. From the lower extremity G, of the system of condensers, a perpendicular tube rises, whose length should be a little more than the most elevated point of the system. The water furnished by the reservoir, L, enters by means of the perpendicular tube through the lower part of the system, and fills the whole space between the double cylinders. When the apparatus is in action, the vapors, as they condense, raise the temperature of the water, which, by the column in L G, is pressed to the upper part of the cylinders, and runs over by the spout K. To this point a very short tube is attached, which is bent towards the ground, and serves as an overflow.



The condensing apparatus is terminated by a conduit in bricks covered and sunk in the ground. At the extremity of this species of gutter is a bent tube E, which discharges the liquid product into the first cistern. When it is full, it empties itself by means of an overflow pipe into a great reservoir; the tube which terminates the gutter plunges into the liquid, and thus intercepts communication with the inside of the apparatus. The disengaged gas is brought back by means of pipes M L, from one of the sides of the conduit to the under part of the ash pit of the furnace. These pipes are furnished with stopcocks M, at some distance in front of the furnace, for the purpose of regulating the jet of the gas, and interrupting, at pleasure, communication with the inside of the apparatus. The part of the pipes which terminates in the furnace rises perpendicularly several inches above the ground, and is expanded like the rose of a watering can N. The gas, by means of this disposition, can distribute itself uniformly under the vessel, without suffering the pipe which conducts it to be obstructed by the fuel or the ashes.

1519. *Benzoic acid.* ($C14+H5+O3+113.$)—This acid is obtained by sublimation from the gum benzoin, as shown in *Ex.* 163, or it may be procured as follows:—

1520. Reduce 3 parts of the gum to a fine powder, and mix it with 1 part of carbonate of soda. The mixture is then to be boiled for half an hour in 24 parts of water, the liquor poured off, and the residuum boiled again with 9 parts of water. The benzoic acid combines with the soda of the carbonate, forming benzoate of soda, which remains in solution, and the carbonic acid is separated with effervescence; the other parts of the benzoin are not dissolved. The mixed decoctions are then filtered and evaporated till only 2 parts remain, and on adding sulphuric acid previously diluted with 7 parts of water, as long as any precipitation takes place, the benzoic acid is thrown down, and sulphate of soda remains in the liquid, from which the benzoic acid is separated by filtration. It is afterwards dried and sublimed to obtain it in the light feathery and crystalline form, in which it is known by the name of Flowers of Benzoin. This is the recipe of the Edinburgh College.

1521. The Dublin College adopt the following process :—5 parts of gum benzoin are triturated with 1 of lime, and boiled in about 100 parts of water. The liquid is then decanted, and the residuum boiled with 70 parts of water, after which these liquids are mixed, evaporated to a half, and filtered through paper. In this manner a solution of the benzoate of lime is obtained, and on decomposing it by adding 1 part of hydrochloric acid; the benzoic acid is precipitated, and the hydrochlorate of lime remains in solution. By filtration, the hydrochlorate of lime is separated, after which the benzoic acid may be washed with a little cold water, and then dried and sublimed.

1522. *Gallic acid.* ($C\,7 + H3 + O5 = 85.$)—Mix powdered galls into a thin paste with water, and expose it for four or five weeks at a temperature of 60 or 70° to the action of the air, observing to prevent its drying up by the occasional addition of a little water. It swells and becomes mouldy, and at the end of that period, contains a large proportion of gallic acid; the paste is dried by pressing out the liquid, which contains scarcely any of the acid in solution, whilst the residue is boiled in water; the solution thus obtained is filtered whilst hot, and as it cools, it deposits gallic acid, which may at once be purified by boiling it with about 8 parts of water and 1 of animal charcoal. The filtered solution now yields pure crystallized gallic acid as it cools. The solution or mixture of galls used for this experiment, consists when first made of tannin only, (with woody fibre, &c.,) when exposed to the air, it parts with a portion of its oxygen and carbon, and is partially converted into gallic acid, the rest remaining tannin still. It is therefore now a mixture of the two, and if an alkali or metallic salt in solution were added, it would form a *tannogallate.* At last the whole of the tannin is decomposed into gallic acid, and being separated as above described from the dross, would upon the addition of an alkali, &c., form a *gallate.* Tincture and infusion of galls are much used as a test for the metals.

1523. *Tannic acid, tannin.* ($C\,18 + H\,9 + O\,12 = 213.$)—To procure this substance in a pure state. Take a long glass tube, with a contracted orifice at both ends—close the lower one loosely with a piece of sponge or linen. Then half fill the tube with powdered galls, then pour common ether upon the galls, and let it percolate through them, catching the drops in a vessel beneath, here they will separate into two portions, one light and fluid, the other dense and yellow; ether is continually added from time to time until the yellow liquid ceases to increase in quantity. The heavier liquid is then separated, washed with more ether, and then evaporated. By this means, a spongy, noncrystallizable produce of pure tannin is obtained, amounting in quantity to more than one-third of the galls employed. It may be made also, but in less proportionate quantity from oak bark, willow bark, horse-chesnut husks, tea, green acorn cups, catechu, and numerous other vegetable matters.

1524. *Succinic acid,* ($C4 + H\,2 + O\,3 = 50,$) is prepared by exposing coarse pieces of amber, after it has been reduced to powder, and mixed with an equal quantity of sand or glass dust, to heat in a green glass or coated flint glass retort, heating the mixture by a table furnace, or a sand-bath. A considerable quantity of oily matter comes over, and succinic acid is deposited in crystals on the neck of the retort and sides of the receiver. The oily liquor which passes over will also show acid properties, but it is in consequence of a little acetic acid which also passes over, in the early part of the process; it may therefore be rejected. The crystals of succinic acid are purified by dissolving them in nitric acid by the aid of heat, and evaporating the liquid to dryness, taking care not to expose the residuum to a temperature sufficient to sublime it, in this manner the empyreumatic oily matter is entirely decomposed, and the succinic acid left quite pure. The only use of this acid is in its union with ammonia, forming the succinate of ammonia, which is a test for certain salts of iron. One pound of amber does not yield more than half an ounce of succinic acid.

1525. *Camphoric acid.* ($C\,10 + H\,8 + 5 = 108.$)—Put into a large retort 4 ounces of powdered camphor, and pour upon it a pint of nitric acid. Then distil it slowly, and when two thirds of the acid have passed over, return it into the retort and distil again. Repeat this operation a third and a fourth time, after which, as the liquid cools, crystals of camphoric acid are deposited. These may be washed and dried. They are soluble in 100 times their weight of cold water, and in about their weight of spirits of wine. Its salts are called camphorates.

There are numerous other acids such as the pectic, carbazotic, mucic, saclactic, stearic, margaric, &c., but these being of no practical utility, are omitted to be further noticed; also it may be observed that gum, sugar, starch, coloring matter, oils, resins, and numerous other vegetable principles are compounds of three elements, but being natural products, and likely to be easily procurable in the ordinary circumstances in which the chemist is placed, they also will be for the present neglected; any important circumstance attending either of them, being introduced as occasion may afterwards require. A similar reason applies to alcohol, although a factitious rather than a natural product, as few persons would be inclined to manufacture it for themselves, and if they were so inclined, the excise laws would interpose unless they operated upon quantities too small to be economically useful.

QUATERNARY COMPOUNDS, OR THOSE COMPOSED OF FOUR ELEMENTS.

Ammonia, though acting with properties similar to the fixed alkalies, and like them a binary substance, yet differs in having no oxygen in its constitution, consequently its compounds with the metallic neutral oxydes, and with all the acids described, are of a four-fold character; nitrogen and hydrogen in the ammonia, and oxygen with the particular base, whatever it may be, in the oxyde. The salts formed by the union of ammonia with the neutral oxydes, such as those of copper, silver, mercury, &c., are called *ammoniurets*; while those of which the acids form a part are named according to the acid, considering ammonia as a base; thus we speak of sulphate of ammonia, acetate of ammonia, &c. A difficulty may arise in consequence of the constitution of the vegetable acids being ternary, yet it will be found that the argument which we adduced in page 146, holds good here, as to the occurrence of one element twice; hydrogen occurs in the ammonia, so it does also in the vegetable acid. In the case of a vegetable acid combining with a metallic oxyde, oxygen occurs twice, the result therefore is in both cases quaternary; so it is also in the instance of ferrocyanic acid, as afterwards more particularly alluded to. This will be evident by the following symbols for these compounds:—

Name.	Constituents.	Symbols.
Sulphate of ammonia =	S + O 3 added to N + H 3	that is S′ + am.
Acetate of ammonia =	C 4 + H 3 + O 3 added to N + H 3	,, Ac′ + am.
Acetate of copper =	C 4 + H 3 + O 3 added to O + Cup	,, Ac′ + cup.
Ferrocyanic acid =	C 2 + N + O added to F + O	,, Cyn′ + F.

AMMONIACAL COMPOUNDS.

Ex. 1526. *Ammoniuret of copper.* (Am + Cu = 49.)—Add ammonia to a solution of the sulphate of copper. The oxyde of the metal will first be separated, and the liquid become cloudy and opaque, then it will be redissolved in the ammonia, the liquid becoming of a most lovely blue. By careful evaporation, dark blue crystals may be obtained, these are a compound salt consisting of sulphate of ammonia, and ammoniuret of copper. Exposed to the air, they lose ammonia, and absorb carbon, becoming then a mixture of sulphate of ammonia and carbonate of copper, and assuming the appearance of a greenish blue crumbling powder.

1527. *Ammoniuret of zinc.*—Steep the oxyde of zinc or else metallic zinc in powder in strong liquid ammonia, a white crystallizable substance will be obtained; if ammonia be added to the sulphate of the metal, a compound salt, called ammonio-sulphate of zinc will be obtained,—this also is white and crystallizable. Zinc is the only metal that ammonia dissolves.

1528. *Ammoniuret of antimony* obtained in like manner.

1529. *Ammoniurets of iron, cobalt, and nickel.*—These are easily formed by the same process, using the protoxyde of the metals.

1530. *Ammoniurets of tin and mercury.*—The peroxydes of these metals are also soluble in liquid ammonia.

1531. *Ammoniuret of silver, detonating silver, argentate of ammonia.*—This as well as some other of the ammoniurets is violently explosive, even while still *wet*. Brande states that the best process for obtaining it, is to pour a small quantity of liquid ammonia upon the oxyde of silver, a portion is dissolved, and a black powder remains, which is the detonating compound. It should only be prepared in small quantities, and handled with the greatest caution, many accidents having arisen from its careless management.

1532. *Ammoniuret of gold, fulminating gold, aurate of ammonia.*—When liquid ammonia is added to a concentrated solution of the chloride of gold, diluted with about 3 parts of water, a yellowish brown precipitate is formed, which, if collected upon a filter, washed with a little water, and carefully dried at the temperature of boiling water is *fulminating* gold. This compound consists of about 5 parts of peroxyde of gold and 1 of ammonia.

1533. *Ammoniuret of platinum, fulminating platinum*, obtained in like manner to the ammoniuret of gold, and possessing similar explosive properties.

1534. Put 2 or 3 grains of either of these detonating ammoniurets upon a cold fire shovel, place the shovel on a slow fire, and there leave it, retiring to a distance; when it arrives at 400° of heat, a most violent explosion will take place. This should be formed in the open air, as the sudden concussion given to the air is very likely to throw down and destroy anything standing around.

1535. Put a minute quantity of one of the fulminates along with a little glass dust on a stone, and rub it with the face of a hammer, immediate explosion will ensue. This fact occasions the fulminate of silver obtained by the above process to be used for Waterloo crackers and other similar objects of amusement.

1536. *To make Waterloo crackers.*—Take 2 slips of stiff paper or card-board about ¼ of an inch wide, and 4 or 5 inches long each; lay a mixture of powdered glass and gum water over one end of each paper for about an inch in length, let this dry, and then put ¼ or an 8th part of a grain of fulminating silver upon the glass on one piece of the paper; place the other piece of paper upon this, so that the glass upon the one shall rest upon the glass of the other, and the free ends of both papers be outwards. Paste a piece of thin paper over the whole covered parts, to attach them to each other. Upon pulling the outward ends of the papers, the two surfaces of glass will grind upon each other, and occasion the explosion of the fulminating silver. When these crackers are made of a larger size, with a grain or more of fulminate, they are used as attachments to a door and doorpost, so that if any one should enter at night, the explosion of the composition may indicate the opening of the door.

1537. Put the amount of about as much as a mustard seed of fulminating silver into a pair of snuffers when quite cold; upon snuffing the candle, it will explode.

1538. Put the same quantity on to a piece of paper pasted over, and while the paste is wet, fasten it with paper all round the head of a pin; stick the pin thus charged in the wick of a candle. When the tallow shall have burnt away down to the pin, the fulminating silver will explode and put out the candle. Let it be remembered, that with this and similar experiments the grease is always scattered.

1539. Put ¼ of a grain in a piece of tinfoil, put it then at the bottom or side of a drawer, and on opening or shutting the drawer, the powder will explode.

1540. Mix the same quantity with glass powder or sand, to which a little weak gum water has been added. .Wrap a little of this mixture in a small piece of thin paper. When dry, throw the ball thus formed with some force against the floor or other hard substance, and detonation will be the result.

1541. If one of these balls be put under the leg of a chair, it will go off when any one sits down in the chair.

1542. As a cheaper material for the above purpose, the ammoniuret of mercury may be used; it is prepared by dissolving the protoxyde of mercury in ammonia, and is nearly as explosive as the ammoniurets of the noble metals, gold, silver, &c. These fulminates should always be kept under water, for when dry, even the falling of them into a phial, or the taking them up with a piece of paper, or the point of a knife may occasion a most terrific explosion.

Chlorate of ammonia. See *Ex.* 1148.

Hydrochlorate of ammonia. See *Ex.*1149.

1543. *Iodide of ammonia.* Into a phial of dry ammoniacal gas, let fall a few grains of iodine, cork the phial and shake it up, the gas and iodine will unite and form a viscid substance at first, of a metallic appearance, afterwards becoming of a brown color. Added to water, it is decomposed into the iodide of nitrogen. See *Ex.* 961.

This brown substance is so very explosive that the warmth of the hands or of the pocket is certain to explode it, and with great violence. When water is added it is dissolved, the solution becoming of a fine crimson color. This is a ternary compound only.

1544. *Iodate of ammonia.* $(\mathrm{I}' + \mathrm{Am.})$—Saturate iodic acid with ammonia. This substance, which forms in small crystals, inflames when thrown upon hot coals, and produces either detonation, or else a flame with the peculiar purple color of iodine.

1545. *Hydriodate of ammonia.* — Add equal volumes of hydriodic and ammoniacal gases together, or else saturate liquid hydriodic acid with liquid ammonia, or with the carbonate of ammonia. Its crystals are very soluble and delisquescent.

1546. *Hydrobromate of ammonia.*—Add bromine to liquid ammonia until neutralized, or else add hydrobromic acid to the same alkali. This salt is volatile, and becomes yellow and slightly acid by exposure to the air.

1547. *Hyponitrate of ammonia.*—Add hyponitrate of lead to sulphate of ammonia. This is soon decomposed by exposure to the air or to heat.

1548. *Nitrate of ammonia.* — Saturate nitric acid with liquid ammonia, or with its carbonate. This is the chief source of nitrous oxyde gas. It was once called *nitrum flammans*, from the circumstance that a crystal of it heated to about 600° in a fire shovel explodes with a loud report.

1549. *Sulphate of ammonia.*—This is a natural product, but may be made in several ways :—1st, by direct combination of the sulphuric acid diluted, and liquid ammonia. 2nd, by adding dilute sulphuric acid to carbonate of ammonia, or the ammoniacal liquor of the gas works. A solution of sulphate of ammonia is thus formed. It may be procured in crystals by evaporation. It is soluble in twice its weight of cold and its weight of boiling water.

1550. *Hypophosphite of ammonia.*—Add hypophosphorous acid to ammonia.

1551. *Phosphite of ammonia.*—Add carbonate of ammonia to phosphorous acid previously dissolved in water. The crystals are deliquescent.

1552. *Phosphate of ammonia.*—Saturate a solution of carbonate of ammonia with phosphoric acid, taking care to leave a slight excess of ammonia. The crystals are efflorescent in the air, and gradually losing ammonia become changed into a biphosphate. The crystals are soluble in 4 times their weight of cold water.

1553. *Biphosphate of ammonia.*— This may be obtained immediately by adding phosphoric acid to the phosphate until it tastes sour, and strongly reddens litmus paper. The crystals remain unchanged in the air. This salt added to an equal quantity of sal ammoniac has been recommended to render linen, lace, &c., waterproof.

1554. *Carbonate of ammonia.*—Add 1 volumn of carbonic acid gas to 2 volumns of ammoniacal gas. They will combine and form the carbonate of ammonia, which thus procured, is a white powder ; when water is added, it becomes a sesquicarbonate.

1555. *Bicarbonate of ammonia.* $(\mathrm{Am}+\mathrm{Car}'2+\mathrm{Water}\ 2=79.)$—Let carbonic acid gas pass through dilute liquid ammonia. The carbonic acid will be absorbed, and uniting with the alkali form a bicarbonate. Also the carbonate and sesquicarbonate of ammonia by being exposed to the air lose their white efflorescent appearance and strong smell, owing to the dissipation of ammonia, and become converted into the bicarbonate, which crystallizes in rhombic prisms.

1556. *Sesquicarbonate of ammonia.* $(\mathrm{Am}+\mathrm{Car}'1\frac{1}{3}+\mathrm{Water}\ 2=59.)$ *Smelling salts. Ammoniæ subcarbonas* of the Pharmacopœia. —Mix together equal portions of chalk and hydrochlorate of ammonia. Subject this mixture to heat in a subliming vessel. A decomposition of the ingredients will take place, the lime will unite with the acid attached to the ammonia, and form the chloride of calcium. The hydrogen therefore of the hydrochloric acid, and the oxygen of the lime unite, and form water. This unites with both the carbonic acid and the ammonia, which are set free, and so uniting forms the sesquicarbonate. It is used in medicine as a stimulant and antacid. It is soluble in 4 times its weight of water, the solution being then called in pharmacy, *liquor ammoniæ subcarbonatis.*

1557. *Biborate of ammonia.* — Saturate boracic acid with ammonia.

1558. *Fluoborate of ammonia.* — Mix together equal volumes of fluoboric acid gas and ammoniacal gas. They will unite, and form a solid compound ; if the quantity of ammoniacal gas be increased, the result is a liquid *subfluoborate.*

1559. *Arseniate of ammonia.*—Add dilute liquid ammonia to arsenic acid to saturation.

1660. *Biarseniate of ammonia.*—Add to a solution of the arseniate another proportional of arsenic, the crystals when formed by evaporation are different from those of the biphosphate of ammonia.

1661. *Chromate of ammonia.*—Saturate chromic acid with ammonia. It forms yellow scales, and is a chromate or bichromate, according to the quantity of water present ; the latter crystallizes in large masses.

THE TARTRATES.

Ex. 1562. *Tartrate of ammonia.*—Add tartaric acid to liquid ammonia ; they will unite and form a very soluble salt, which is the tartrate ; if more acid be used than is sufficient to neutralize the alkali, a *bitartrate* is formed; this being soluble with difficulty will be thrown down from the solution. This is so copious in quantity that if the solutions used be saturated, the result is a solid mass, of a white color, considerable heat being at the same time extricated.

1563. *Bitartrate of potass, supertartrate of potass*, commonly called *tartar, argol*, or *winestone*. This is deposited in considerable quantities in casks of wine. It is purified by first dissolving in hot water, then crystallizing, it thus becomes white, and when pulverized is *cream of tartar*. Should the tartar contain much coloring matter in the first instance, it is necessary to boil it for some time along with about a twentieth of its weight of pipeclay, and the same quantity of ivory black, (animal charcoal) by which the coloring matter is separated. It is slightly acid, and in a very *slight* degree soluble in water, requiring about 12 gallons of water to dissolve an ounce of the bitartrate.

1564. *Fox's soluble cream of tartar*, or *sal-gummosum, tartarus boraxatus* of old authors, is cream of tartar which is rendered more soluble by the addition of rather more than one-third part of borax, an effect which this salt as well as boracic acid has upon it.

1565. *Tartrate of potass.*—Add potass to cream of tartar in water, the excess of acid will be neutralized by the potass, and a tartartrate be formed. This is soluble in less than twice its weight of water; hence it is called *soluble* tartar, as a name sufficiently distinctive of its comparative solubility with the bitartrate.

1566. *Tartrate of soda.*—A mixture of tartaric acid and the carbonate of soda. This is the salt held in solution after mixing these ingredients together in a tumbler as a beverage, and which is so well-known as *soda* water. The salt may be obtained in crystals by evaporation. It is soluble in about its own weight of water. If more than a sufficiency of acid be used, a *bitartrate* is formed, but this is also soluble, it therefore differs materially from the bitartrate of potass.

1567. *Tartrate of lime.*—Add chalk to tartar as in the process of forming tartaric acid. See *Ex.* 1501. It is soluble in cold water, but soluble in 600 parts of hot water.

1568. *Tartrate of baryta.*—Add a solution of tartaric acid to the carbonate of baryta.

1569. *Tartrate of strontia.*—Mix together tartrate of potass and nitrate of strontia both in solution. After some hours the tartrate of strontia will be thrown down. It is very sparingly soluble in water.

1570. *Tartrate of magnesia.*—Add tartaric acid to a solution of the sulphate or carbonate of magnesia.

1571. *Tartrate of manganese.*—Boil together equal weights of the protoxyde of manganese and tartaric acid water, a colorless solution of the prototartrate is obtained; if required in crystals, the liquid is to be poured off, evaporated, and crystallized.

1572. *Tartrate of iron.*—Pour a strong solution of tartaric acid upon iron filings, they will dissolve, and form a prototartrate, which is white and scarcely soluble in water. It may also be formed by adding tartrate of potass to protosulphate of iron in solution. The prototartrate of iron thus formed, will upon cooling be deposited in crystals, while the sulphate of potass will fall immediately as a white powder.

1573. *Tartrate of zinc.*—Mix tartrate of potass with sulphate of zinc.

1574. *Tartrate of tin.*—Mix tartarte of potass with the protochloride or perchloride of tin.

1575. *Tartrate of copper*, procured as the tartrate of zinc.

1576. *Tartrate of lead.*—Add tartaric acid to a solution of nitrate or acetate of lead. When this tartrate is heated to a dull red in a glass tube, it acquires a brown color, and, when cool, forms a very perfect *pyrophorus*, which immediately inflames on being shaken out into the air. This property appears to depend upon the rapid oxydizement of the minutely-divided metallic lead.

1577. *Tartrate of antimony*, procured as the tartrate of manganese.

1578. *Tartrate of cobalt.*—Dissolve oxyde of cobalt in tartaric acid, the crystals yielded by evaporation are of a red color.

1579. *Tartrate of nickel*, formed in like manner.

1580. *Tartrate of mercury*, obtained in like manner.

1581. *Tartrate of silver.*—Add tartrate of potass to nitrate of silver; the result is the white tartrate of silver.

1582. *Tartrate of alumina.*—Add tartaric acid to alumina.

OXALATES.

Ex. 1583. *Oxalate of ammonia.* $(\mathrm{Ox}'+\mathrm{Am.})$—Saturate a solution of oxalic acid with ammonia. It forms upon evaporation prismatic crystals soluble in about 20 times their weight of cold water, and in 4 times their weight of boiling water.

1584. *Oxalate of potass.* $(\mathrm{Ox}'+\mathrm{P.})$—This may be made by the direct process of saturating the acid by the alkali, or by fusing together sugar or other vegetable product, with their weight of caustic potass. If the heat be so great as to char the ingredients, the whole will be converted into carbonate of potass.

1585. *Binoxalate of potass.* (2 Ox′ + P.) —Dissolve the oxalate in oxalic acid.

1586. *Quadroxalate of potass.* (4 Ox + P.) —Digest the binoxalate of potass in nitric or hydrochloric acid, half the potass is hereby extracted, and a quadroxalate remains. These three salts are all soluble in both hot and cold water.

1587. *Oxalate of soda.*—Add carbonate of soda to oxalic acid.

1588. *Oxalate of lime.*—Add oxalic acid or oxalate of ammonia to any salt of lime or to lime water. The oxalate falls as a white powder, insoluble in excess of oxalic acid. When drying upon the sand bath, this salt becomes singularly electrical and phosphorescent.

1589. *Oxalates of baryta, strontia, magnesia, and manganese,* are formed in the same manner as that of lime. They are all of a white color, and nearly insoluble in cold water. In producing that of magnesia, some time elapses before the precipitate falls down.

1590. *Protoxalate of iron.*—Add the protoxyde of iron to a solution of oxalic acid. It crystallizes in green prisms.

1591. *Peroxalate of iron.*—Add oxalic acid to a solution of the perchloride or persulphate of iron, a precipitate of a yellow color is first produced, and afterwards this precipitate is dissolved in the added acid.

1592. *Removing ink spots from books, linen, furniture, &c.*—Ink spots are a deposition of gallotannate of iron; this is decomposed by dropping upon them oxalic acid, which changes the gallate into an oxalate, and which may be washed away. Ink is also decomposed by the soap and soda used in washing, which deprive it of its component acid, but leave the peroxyde of iron commonly called *iron mould* on the linen. As oxalic acid dissolves this forming with it as before an oxalate soluble in excess of oxalic acid, it is evident that its application will remove these unsightly stains, and is the best substance which can be used for that purpose; a few drops of its solution may be rubbed on the furniture, book, &c., or suffered to remain dropped upon it for a few minutes until the bleaching is completed.

1593. *Oxalate of tin and copper.*—Pour upon filings of the metals a strong solution of oxalic acid, the metals will dissolve if assisted by heat, and an oxalate be formed. That of copper is a green powder, which may be crystallized; the crystals however are a binoxalate.

1594.—*Oxalates of lead, bismuth, cobalt, nickel, mercury, silver, and chromium.*—Add oxalic acid to solutions of the nitrates of the various metals. The oxalate of nickel is green, that of copper red; the solution of that of chromium appears red if looked *through*, but green if looked *at*. This last is very soluble, the rest insoluble in water, and of a white color; that of silver become black by exposure to light.

1595. *Oxalate of alumina.*—Add the earth to a solution of oxalic acid. This oxalate does not crystallize, but forms a jelly-like substance.

CITRATES.

Ex. 1596. *Citrate of potass, salt of Riverius.*—Add citric acid to potass, in the proportion of 7½ parts of the former to 7 of the latter. This salt, which like most of the rest of the citrates is soluble in water, is used in medicine as a mild diaphoretic.

1597. *Citrate of soda.*—Add citric acid in solution to soda or its carbonate.

Citrate of lime. See *Ex.* 1507.

1598. *Citrate of manganese.*—Add protoxyde of manganese to citric acid. It forms white crystals.

1599. *Citrates of baryta and strontia.*—Add the acid to baryta water or strontia water. A curdy white precipitate from each will be formed. These citrates may be better obtained by mixing together solutions of the nitrates of baryta or strontia, with oxalate of potass, and boiling the mixture. The oxalates will fall down, and nitrate of potass be held in solution.

1600. *Citrate of iron.*—Add a solution of citric acid to iron filings, citrate of iron will upon evaporation be deposited as a white powder. Exposed to the air, it becomes first yellow, then greenish, being converted by such exposure into a precipitate.

1601. *Citrate of zinc.*—Prepared by adding together the acid in solution with the filings of the metal.

1602. *Citrate of copper.*—Add citric acid to a solution of nitrate or sulphate of copper; the precipitate is of a pale blue.

1603. *Citrate of lead,* procured as the citrate of copper. It is a white, nearly insoluble powder. Berzelius recommends, as a superior process, to add an alcoholic solution of citric acid to a solution of acetate of lead; then to wash the precipitate with alcohol.

1604. *Citrates of mercury, silver, &c.,* procured as the citrate of copper, or by adding the citrate of potass to the salts of these metals.

ACETATES.

Ex. 1605. *Acetate of ammonia.*—Saturate distilled vinegar with carbonate of ammonia. It dissolves in its own weight of cold water, and is deliquescent in the air. It was used in medicine, and was once called *the Spirit of Mindererus.*

1606. *Acetate of potass.*—Obtained in like manner. It is soluble in its own weight of cold water, and in half its weight of boiling alcohol. It is deliquescent in the air.

1607. *Acetate of soda.*—Add acetic acid to the carbonate. It is not soluble in less than 3 times its weight of cold water, and scarcely at all in alcohol. It is efflorescent in the air.

1608. *Acetate of lime.*—Obtained in like manner. This is efflorescent, and forms silky needle-shaped crystals, soluble in hot and cold water, and alcohol.

1609. *Acetates of baryta and strontia.*—Obtained in like manner; both form white crystals.

1610. *Acetate of magnesia.*—This is deliquescent, and will not crystallize; but when dry resembles a gummy mass.

1611. *Protacetate of iron.*—Add acetic acid to the proto-sulphuret of iron. It forms upon filtration and evaporation a mass of silky white needle-shaped crystals.

1612. *Peracetate of iron.*—Mix acetate of lead with sulphate of iron, or else dissolve peroxyde of iron in acetic acid. The solution formed is of a brownish red color, which when inspissated does not crystallize, but forms a gum-like mass. This solution is much employed by calico printers and dyers.

1613. *Acetate of zinc.*—Mix sulphate of zinc with acetate of lead, both in solution; or else dissolve oxyde of zinc in acetic acid. It crystallizes in thin shining white plates, soluble, but not deliquescent. This is used as an external application to wounds, &c.

1614. *Acetate of tin.*—This metal is slowly acted on by acetic acid, but a *protacetate* and peracetate of tin may be obtained by mixing acetate of lead with saturated solutions of the protochloride and perchloride of tin.

1615. *Acetate of cobalt.*—Dissolve oxyde of cobalt in acetic acid. The solution is pink, and yields red crystals, which become green when heated. This is the sympathetic ink mentioned in *Ex.* 923.

1616. *Acetate of nickel.*—Dissolve the carbonate of nickel in acetic acid. The solution is of a dark green; when evaporated the crystals are also dark green; soluble in water, but not in alcohol. If these crystals be subjected to heat they become yellow, give out water, then burn like tinder, and leave oxyde of nickel.

1617. *Acetate of copper, crystallized verdigris, subacetate of copper, &c.*—When copper in filings or shreds is submitted to the action of acetic acid it becomes corroded, and a subacetate is formed. This is commonly known in commerce as *common verdigris.* If this crude substance is dissolved in acetic acid, and the solution is put into pans, and allowed to crystallize slowly upon pieces of twigs or strings suspended in the solution, it forms fine, rich green prismatic crystals, soluble in 5 parts of boiling water. This is the true acetate, and is much used by the painter under the name of *distilled or crystallized verdigris.*

1618. To a boiling solution of acetate of copper add brown sugar. The acetate will be decomposed, and a red crystalline powder subside.

1619. *French verdigris.* This is made by mixing pieces of copper with the stalks and leaves of grape vines. The acetic acid contained in these acts upon the copper, and converts it at once into subacetate.

1620. *Subsesquiacetate of copper.*—Mix the subacetate, previously pounded, with water, and rub them together, until a saturated solution is obtained. Next filter, and slowly evaporate until a dry powder is obtained; continue the heat until the salt is melted, then add alcohol. The solution being set aside, a gelatinous mass of minute crystals is formed, which when dry are of a pale blue color.

1621. *Triacetate of copper.*—Mix common verdigris with water; a part of it dissolves—the rest is insoluble. This is the triacetate of copper.

1622. *Acetate of lead, sugar of lead, salt of Saturn,* ($\mathrm{Pl}+\mathrm{Ac}'$,) is prepared by digesting oxyde of lead, (litharge,) in pyroligneous acid, or in vinegar; or else by exposing plates of lead to the fumes of vinegar. By this latter method they become incrusted with a white powder, which is the carbonate of lead, as was explained in *Ex.* 1403. This carbonate is then dissolved in acetic acid, which thereby forms sugar of lead, or the acetate required. This salt is much used by the calico printer and by the painter; the latter on account of its drying qualities, as when ground up with oil or turpentine, and added to ordinary oil paint, it enables it to dry very rapidly, in consequence of its absorbing the greasy properties of the oil.

1623. *Diacetate of lead.*—Formed by boiling litharge in a solution of the acetate; the proportion of litharge being twice that taken up by the acetic acid in forming the acetate. On evaporation it forms a white crystalline sediment, sweet in taste, and soluble in water.

1624. *Trisacetate of lead.*—Obtained in like manner, using an additional proportion of litharge; about 15 parts of the litharge to 10 of the acetate are to be used. Of this about 6 parts are dissolved, and the solution filtered and evaporated leaves an uncrystallizable trisacetate. Its solution is well known as Goulard water or Goulard's extract; and is the *liquor plumbi subacetatis* of the Pharmacopæia.

1625. *Hexacetate of lead.*—Add ammonia in excess to a solution of acetate of lead. A white powder is obtained sparingly soluble in water.

1626. *Acetate of antimony.*—Dissolve the protoxyde in acetic acid.

1627. *Acetate of bismuth.*—Add acetate of potass to a solution of the nitrate of bismuth.

1628. *Protacetate of mercury.*—Make a solution of the protonitrate of mercury, and also one of the acetate of potass; then pour the mercurial solution into that of the acetate.

1629. *Peracetate of mercury.*—Boil peroxyde of mercury in acetic acid.

1630. *Acetate of silver.*—Procured in the same manner as the protacetate of mercury; using for its formation a strong solution of the nitrate of silver, and a weak one of the acetate of soda. It is precipitated as a white nearly insoluble powder. This is the most insoluble of all the acetates.

1631. *Acetate of alumina.*—If this be required in small quantity it may be obtained by adding acetic acid to the earth alumina, but if required in larger quantity it may be manufactured as follows:—About 3 lb. of alum are dissolved in 8 gallons of water, and 1½ lb. of sugar of lead stirred in it, a copious formation of sulphate of lead ensues, which is allowed to subside, and the clear liquor holding acetate of alumina, and a portion of undecomposed alum in solution is then drawn off; a portion of pearlash and chalk being then added to it previous to use, in order to neutralize any excess of acid. It is used by calico printers and dyers as a mordant for fixing a great variety of colors. It may also be made by adding a solution of acetate of lime to another of alum; it is deliquescent in the air. Gay Lussac remarks that a solution of the acetate of alumina becomes turbid when heated, but recovers its transparency when again cooled.

THE TANNATES AND TANNOGALLATES.

The close connexion of the tannic and gallic acid have been already observed upon, and their compounds with the alkalis and metals are also often confounded, so that one author calls the whole by the same name. The tannogallic acid, or a solution of galls, precipitates the metals of various colors from their solutions; hence this substance is a valuable test for very many of them, as will be explained under the chapter tests. Thus a solution of galls precipitates iron and osmium purple or blue black, as we see in common writing ink. The tannogallate of nickel is yellowish green; those of tin, mercury, and silver, yellow; of lead, cobalt, and antimony, white; bismuth, orange; gold, brown; platinum of an olive color, &c. The following tannate of iron is the only one which is valuable, though tannates of numerous of the metals and alkalis, &c. are easily procurable; they are mostly insoluble, or nearly so. The following receipts for numerous inks, though not depending upon the action of tannic acid, except the black inks, may be useful:—

1632. *Black ink.*—Nut galls, sulphate of iron, and gum, are the only substances truly useful in the preparation of ordinary ink. The other things often added merely modify the shade, and considerably diminish the cost to the manufacturer upon the great scale. Many of these inks contain little tannic acid, or tannin, and are therefore of inferior quality. To make 12 gallons of ink we may take—12 lbs. of nutgalls, 5 lbs. of green sulphate of iron, 5 lbs. of gum senegal, and 12 gallons of water. The bruised nutgalls are to be put into a cylindrical copper, of a depth equal to its diameter, and boiled during three hours with three-fourths of the above quantity of water, taking care to add fresh water to replace what is lost by evaporation. The decoction is to be emptied into a tub, allowed to settle, and the clear liquor being drawn off, the lees are to be drained. Some recommend the addition of a little bullock's blood, or white of egg, to remove a part of the tannin. But this abstraction tends to lessen the product, and will seldom be practised by the manufacturer intent upon a large return for his capital. The gum is to be dissolved in a small quantity of hot water, and the mucilage, thus formed, being filtered, is added to the clear decoction. The sulphate of iron must likewise be separately dissolved, and well mixed with the above. The color darkens by degrees, in consequence of the peroxidizement of the iron, on exposing the ink to the action of the air. But ink affords a more durable writing when used in the pale state, because its particles are then finer, and penetrate the paper more intimately. When ink consists chiefly of tannate of peroxide of iron, however black, it is merely superficial, and is easily erased or effaced. Therefore whenever the liquid made by the above prescription has acquired a moderately deep tint, it should be drawn off clear into bottles, and well corked up. Some ink-makers allow it to mould a little in the casks before bottling, and suppose that it will thereby be not so liable to become mouldy in the bottles. A few bruised cloves, or other aromatic perfume, added to ink, is said to prevent the formation of mouldiness, which is produced by the growth of a minute fungus.

The operation may be abridged by peroxidizing the copperas beforehand by moderate calcination in an open vessel; but for the reasons above assigned ink made with such a sulphate of iron, however agreeable to the ignorant, when made to shine with gum and sugar, under the name of japan ink, is neither the most durable, nor the most pleasant to write with. The ink made by the prescription given above is much more rich and powerful than many of the inks commonly sold. To bring it to their standard, a half more water may safely be added, or even 20 gallons of tolerable ink may be made from that weight of materials. Lewis, who made exact experiments on inks, assigned the proportion of 3 parts of galls to 1 of sulphate of iron, which with average galls will answer very well; but good galls will admit of more copperas.

1633. *Gold ink.*—Mix the powder of *Ex.* 519 with weak gum water.

1634. *Silver ink* is obtained in like manner with silver leaf.

1635. *Indelible ink.* See *Ex.* 1268.

1636. *Red ink.*—This ink may be made by infusing for three or four days in weak vinegar, Brazil wood chipped into small pieces; the infusion may be then boiled upon the wood for an hour, strained, and thickened slightly with gum arabic and sugar. A little alum improves the color. A decoction of cochineal with a little water of ammonia, forms a more beautiful red ink, but it is fugitive. An extemporaneous red ink of the same kind may be made by dissolving carmine in weak water of ammonia, and adding a little mucilage.

1637. *Green ink.*—According to Klaproth a fine ink of this color may be prepared by boiling a mixture of 2 parts of verdigris in 8 parts of water, with 1 of cream of tartar, till the total bulk be reduced one-half. The solution must be then passed through a cloth, cooled, and bottled for use.

1638. *Yellow ink* is made by dissolving 3 parts of alum in 100 of water, adding 25 parts of Persian or Avignon berries bruised, boiling the mixture for an hour, straining the liquor, and dissolving it in 4 parts of gum arabic. A solution of gamboge in water forms a convenient yellow ink.

By examining the different dye-stuffs, and considering the processes used in dyeing with them, a variety of colored inks may be made.

1639. *Blue ink.*—Dissolve the sulphate of indigo in water; this is what is used to rule account books.

1640. *China ink.*—Proust says, that lamp black purified by potash-lye, when mixed with a solution of glue, and dried, formed an ink which was preferred by artists to that of China. M. Merimée gives the following directions for preparing this ink with glue. Into a solution of glue he pours a concentrated solution of nut-galls, which occasions an elastic resinous-looking precipitate. He washes this matter with hot water, and dissolves it in a spare solution of clarified glue. He filters anew, and concentrates it to the proper degree for being incorporated with the purified lamp black. The astringent principle in vegetables does not precipitate gelatine when its acid is saturated, as is done by boiling the nut-galls with lime water or magnesia. The first mode of making the ink is to be preferred. The lamp black is said to be made in China by collecting the smoke of the oil of sesame. A little camphor, (about 2 per cent.) has been detected in the ink of China, and is supposed to improve it. Infusion of galls renders the ink permanent on paper.

Sympathetic ink. See *Ex.* 922, 923.

THE FULMINATES.

The detonating compounds, so much used for percussion caps for fire-arms and for other similar purposes, are the combinations of a peculiar acid, called the fulminic acid, the constituents of which seem to be $N\,2 + C\,4 + O\,2$. This acid cannot be obtained in a free state from any of its salts, which are all of them quaternary, being decomposed at the moment of its separation by any other acid into hydrocyanic acid and a new product. This acid is formed when the nitrate of silver or protoxyde of mercury, with an excess of nitric acid, is boiled in alcohol, as follows:—

Ex. 1641. *Fulminate of protoxyde of mercury.* (2 Prot. Hyg + 1 Acid.) The following is the important process given by Dr. Ure to form the fulminate of mercury:—100 parts, by weight of mercury must be dissolved with a gentle heat in 1000 parts (also by weight) of nitric acid, spec. gr. 1.4; and this solution, at the temperature of about 130° Fahr. must be poured into 830 parts by weight of alcohol, spec. gr. 0·830. *Note.* 830 parts of such alcohol, by weight, constitute 1000 by measure; and 1000 parts of such nitric acid by weight constitute 740 by measure. Hence, in round numbers, 1 ounce weight of quicksilver must be dissolved in 7½ oz. measures of the above-designated nitric acid, and the resulting solution must be poured into 10 oz. measures of the said alcohol. The mercury should be dissolved in the acid in a glass retort, the beak of which is loosely inserted into a large balloon or bottle of glass or earthenware, whereby the offensive fumes of the nitrous gas disengaged during the solution, are in a considerable measure condensed into liquid acid, which should be returned into the retort. As soon as the mercury is all dissolved, and the solution has acquired the prescribed temperature of about 130°, it should be slowly poured through a glass or porcelain funnel into the alcohol contained in a glass matrass or bottle, capable of holding fully six times the bulk of the mixed liquids. In a few minutes bubbles of gas will proceed from the bottom of the liquid; these will gradually increase in number and magnitude till a general fermentative commotion, of a very active kind, is generated, and the mixture assumes a somewhat frothy appearance. A white voluminous gas now issues from the orifice of the matrass, which is very combustible, and must be suffered to escape freely into the air, at a distance from any flame. These fumes consist of an etherous gas, holding mercury in suspension or combination. When this is not allowed freely to come off, a portion of subnitrate or nitrate of mercury is apt to be formed, to the injury of the general process and the product.

As soon as the effervescence and concomitant emission of gas are observed to cease, the contents of the matrass should be turned out upon a paper double filter, fitted into a glass or porcelain funnel, and washed by the affusion of cold water till the drainings no longer redden litmus paper. The powder adhering to the matrass should be washed out, and thrown on the filter by the help of a little water. Whenever the filter is thoroughly drained, it is to be lifted out of the funnel, and opened out on plated copper or stone ware, heated to 212° Fahr. by steam or hot water. The fulminate being thus dried is to be put up in paper parcels of about 100 grains each; the whole of which may be afterwards packed away in a tight box, or a bottle with a cork stopper. The excellence of the fulminate may be ascertained by the following characters: — It consists of brownish-grey small crystals which sparkle in the sun, are transparent when applied to a slip of glass with a drop of water, and viewed by transmitted light. These minute spangles are entirely soluble in 130 times their weight of boiling water; that is to say, an imperial pint of boiling water will dissolve 67 grains of pure fulminate. Whatever remains indicates impurity. From that solution beautiful pearly spangles of fulminate fall down as the liquid cools.

1642. *Properties of.*—Fulminate of mercury is obtained in white grains, or short needles, of a silky lustre, which become grey upon exposure to light, and detonate either by a blow or at a heat under 370° Fahr.; with the disengagement of azote, carbonic acid, as also of aqueous and mercurial vapors, to the sudden formation of which gaseous products the report is due. It detonates even in a moist condition; and when dry it explodes readily when struck between two pieces of iron, less so between iron and bronze, with more difficulty between marble and glass, or between two surfaces of marble or glass. It is hardly possible to explode it by a blow with iron upon lead; and impossible by striking it with iron upon wood. It fulminates easily when rubbed between two wooden surfaces; less so between two of marble, two of iron, or one of iron against one of wood or marble. The larger its crystals, the more apt they are to explode. By damping it with 5 per cent. of water, it becomes less fulminating; the part of it struck still explodes with a proper blow, but will not kindle the adjoining portion. Though moistened with 30 per cent. of water, it will occasionally explode by trituration between a wooden muller and a marble slab, but only to a small extent, and never with any danger to the operator. When an ounce of it, laid upon the bottom of a cask, is kindled, it strikes a round hole down through it, as if it had been exposed to a four-pound shot, without splintering the wood. If a train of fulminate of mercury be spread upon a piece of paper, covered with some loose gunpowder, in exploding the former the latter will not be kindled, but merely scattered. When gunpowder, however, is packed in a cartridge or otherwise, it may be certainly kindled by a percussion cap of the fulminate, and more completely than by a priming of gunpowder. 8½ parts of gunpowder exploded by a percussion cap have an equal projectile force as 10 exploded by a flint lock. If we add to this economy in the charge of the barrel, the saving of the powder for priming, the advantage in military service of the percussion system will become conspicuous.

1643. *Fulminate of silver.*—Prepare a solution of nitrate of silver, and pour into it a solution of pure lime in water, as long as a precipitate will fall down. Filter the liquid, and wash the precipitate by pouring warm water on it, as it stands on the filter. Now put the powder into a warm place upon paper, that it may be well dried; then put it into a wide-mouthed phial, containing pure liquid ammonia—cork it, and let it remain undisturbed for a whole day, or until the powder becomes black. Now pour off the supernatant liquor, and put the phial open, in a place where the heat may not be more than 80° or 100°. When dry, this powder is very explosive, and should remain undisturbed in the phial where the process was finished; as sometimes the least friction will cause an explosion of the whole mass. The lid of a pill-box is the best cover the phial can have, as frequently in taking the powder out a part adheres to the neck; and then if a stopper or cork be put in, the friction occasioned even by this is sometimes sufficient to explode the whole. Perhaps, if all fulminating powders were dried in watch glasses, and permitted to remain in them till wanted for use it would be much safer.

1644. *Fulminate of gold.*—Prepare a solution of gold in nitro-muriatic acid, and pour it into a tumbler or ale glass. Into this solution pour pure liquid ammonia, as long as a precipitate falls down; but the instant in which the precipitate begins to disappear, (which will be by *re-solution* by means of the alkali,) desist. Now filter the liquid; and when the solution of muriate of ammonia has passed through, pour some warm water on the powder in order to wash it well. When this water has also passed through dry the precipitate, by merely laying the paper on which it lies on the table, or in a window, because if dried near the fire it may explode. Take care also that no person or thing may touch this powder, as the least friction will cause an explosion of the whole.

1645. *Fulminate of copper.*—Dissolve some pure copper in diluted nitric acid, and pour into it some liquid ammonia as long as a precipitate falls down. Pour the solution into an evaporating dish, and expose it to a tempetature of 200° until the precipitate is merely in a moist state. Now place the dish in a lower temperature, until the powder is quite dry. Preserve it in a wide-mouthed phial, loosely covered with paper.

1646. *Fulminate of platinum.*—Prepare a solution of nitro-muriate of platinum, and pour it into liquid ammonia, as long as a precipitate falls down. Filter the liquid, and pour water over the powder on the filter in order to wash it. Put this powder into a small vessel with a solution of pure potass; and give it a boiling heat, until all the water has evaporated. Pour several waters over the residuum, in order to wash it well; when the fluid that comes off is tasteless, put the remaining powder on paper, and dry it by a heat not exceeding 200°. The fulminating powder thus obtained is of a brownish color. Too much should not be prepared at one time, and it should be preserved in the same way as the fulminating gold.

Any of the experiments given under paragraph may be tried with these various compounds, and with similar, or even more terrific results.

1647. *Fulminate of zinc, fulminic acid.*—According to E. Davy this may be procured by digesting the fulminate of mercury with metallic zinc. From the solution, which contains no longer a trace of mercury, baryta precipitates half the zinc; and a fulminate of zinc and baryta is obtained. From this the baryta may be precipitated by sulphuric acid, and the acid fulminate of zinc remains in solution, which has been described by E. Davy and Brande as pure fulminic acid, and which is the nearest substance to the pure acid hitherto obtained; although, as Dr. Turner justly remarks, it contains zinc in solution.

THE ALKALOIDS.

The discovery of these substances may be dated from 1817. It was made by Serteurner, but it remained unnoticed or doubted for ten years, till the Institute of France thought proper to pay attention to it. From that time chemists became eager to discover the alkalis of all the plants possessed of any remarkable properties; and substances whose names end in *ine* were multiplied as profusely, and on as slight grounds as the vegetable acids.

The alkaloids are all composed of four elements, oxygen, hydrogen, carbon, and nitrogen united in extremely variable proportions. The same mode of preparation is employed for them all. A watery solution of the vegetable matter is evaporated; the base is precipitated by an alkali, that is by boiling it with magnesia; and the vegetable alkaloid is dissolved by pure boiling alcohol, and obtained on cooling or by distillation. The foreign matters which the precipitate may have carried along with it are removed either by a diluted solution of potash, or by boiling with a weak acid and animal charcoal: after which the alkaloid is again precipitated by the addition of an alkali.

These substances are little soluble in water with the exception of *curarine* and *nicotine.* Most of them restore the color of turnsole reddened by an acid, and turn the syrup of violets green. Their taste is, in general, bitter; and they give this bitterness to water, even when it scarcely dissolves an appreciable quantity of them. They unite with acids, and form salts which are much more soluble than their bases; but their capacity of saturation is very small. The greater part of them, as well as the salts which they form, are capable of crystallizing; but some of them, when dried, form only gummy masses. Chemists regard these products as the active principles of vegetables, and consequently as natural products of vegetation.

The principal alkaloids are morphine, narcotine, strychnine, brucine, quinine and cinchonine, veratrine and emetine.

1648. *Morphine.* ($C 34 + H 18 + O 6 + N 1 = 284.$)—Discovered by Serteurner in opium. This substance is nearly insoluble in cold water, though it gives it a bitter taste. It is soluble in 100 times its weight of boiling water, and precipitates from this solution as it cools, in the form of small brilliant colorless crystals. Its solution restores the color of turnsole reddened by an acid, and changes the yellow of turmeric to brown. It is soluble in 40 times its weight of pure alcohol, when cold, and in 30 times its weight of boiling alcohol. It is soluble also in the fixed and volatile oils, and in solution of potash and soda, and to a small degree in ammonia.

1649. *Narcotine.* ($C 80 + H 20 + O 12 + N 1 = 370.$)—This substance is not alkaline, and it rather dissolves in the acids than combines with them. It is destitute of taste, insoluble in cold water, soluble in 400 times its weight of boiling water, in 100 of cold alcohol, and in 24 of boiling alcohol, in cold ether, and still more so in hot ether, and in the fixed and volatile oils. It does not act on the salts of iron. It is separated from morphine by ether, which does not attack the latter.

1650. *Strychnine.* ($C 30 + H 16 + O 3 + N 1 = 234.$)—Extracted in 1818 by Pelletier and Caventou from plants of the genus *Strychnos*, and especially from the *Nux Vomica.* It crystallizes by spontaneous evaporation from its alcoholic solution in small white quadrilateral prisms, terminated by pyramids. It is alkaline, bitter with a metallic after-taste, does not melt or volatilize by heat, but is decomposed between 593° and 600°. It is soluble in 2500 times its weight of boiling water, and in 6667 of cold water. It is insoluble in ether and pure alcohol, but soluble in the volatile oils, and to a small degree in the fixed oils, as well as in boiling alcohol of sp. gr. .835. It is decomposed by the action of melted sulphur, giving out hydro-sulphuric acid.

1651. *Brucine.* ($C 32 + H 18 + O 6 + N 1 = 272.$)—Extracted by Pelletier and Caventou from the bark of the *Strychnos Nux Vomica*, and not as had been thought, from the *Brucea antidysenterica*, from which its name is taken. It is soluble in 850 times its weight of cold water, and in 500 of boiling water, in pure alcohol, and even in spirit of wine, sp. gr. .839. It is soluble also to a small degree in the volatile oils, but insoluble in ether, and the fixed oils. Strychine always contains a small portion of brucine.

1652. *Quinine* and *cinchonine.*—Cinchonine was discovered almost at the same time by Duncan, Gomez, Lambert, and Pfaff, in the bark of the *Cinchona.* Pelletier and Caventou established its alkaline nature, and in the course of their researches on it discovered quinine. The latter is obtained either in masses or powder, while the other is crystalline. Quinine is soluble in 200 times its weight of boiling water, but cinchonine requires 2500 times its weight. It is soluble, to a considerable extent, in boiling alcohol, though less so than quinine. The latter is soluble, to a considerable extent, in ether, which is scarcely capable of dissolving the former. Cinchonine is decomposed, and partly volatilized by heat, without melting. They both form soluble salts with the mineral acids and with acetic acid, and insoluble salts with other acids. The sulphate of quinine is much less soluble than that of cinchonine. Quinine is separated from cinchonine by means of ether or sulphuric acid, or by boiling water. Cinchonine is extracted principally from the pale bark; both of them are alkaline. Cinchonine is composed of $C 20 + H 11 + O 1 + N 1 = 153.$ Quinine has 1 atom more of hydrogen, and 1 more of oxygen. Its constitution therefore is $C 20 + H 12 + O 2 + N 1 = 162.$

1653. *Veratrine.* ($C 34 + H 22 + O 6 + N 1 = 288.$)—This substance was discovered at the same time by Meisner, and by Pelletier and Caventou, in the seeds of the *Veratrum sabadilla*, and in the root of the *Colchicum autumnale.* It is uncrystallizable, alkaline, and possesses a sharp burning taste without any bitterness, but no smell, though strongly sternutatory. It melts at 122°. It is almost insoluble in cold water, but soluble in 1000 times its weight of boiling water. It is very soluble in alcohol and in oil of turpentine by the aid of heat, but insoluble in pure ether.

1654. *Emetine.*—Discovered by Pelletier in the root of the *Cephaelis Ipecacuanha.* It is of a fawn color, and alkaline. It has a weak bitter taste, and no smell. It is difficultly soluble in cold water, but more so in hot water. It melts easily somewhat below 120°. It is very soluble in alcohol, but almost insoluble in ether and the oils. Its salts are as well as itself *uncrystallizable.* The infusion of galls throws it down from its solution in the form of a white precipitate.

It would exceed the limits of this work to give a detailed description of all the proximate alkaloid principles which have encumbered science within the last few years. We shall content ourselves with naming *Curarine*, extracted by Boussingault and Roulin from the *Curari* or *Urali*, a substance which the Indians of South America use for poisoning their arrows; ***Esenbeckine***, found by Buchner in the ***Esenbeckia febrifuga; Capsicine***, found by Wilting in the ***Capsicum annuum; Aconitine*** obtained by Peschier from the ***Aconitum Napellus; Conicine*** extracted by Brandes from the ***Cicuta virosa*** and ***Conium maculatum; Crotonine***, extracted by Brandes from the seed of the ***Croton tiglium; Buxine***, which Fauré announced his having found in the ***Buxus sempervirens; Eupatorine***, which Riphini has discovered in the ***Eupatorium Cannabinum; Corticine*** and ***Populine*** which Braconnot has found in the bark of the ***Populus tremens;*** and, lastly, ***Salicine***, which the same chemist, and Leroux found in that of the ***Salix alba***, and to which Peschier has directed the attention of physicians as a substitute for quinine. It is extracted by precipitating the tannin from a strong decoction of the bark by means of slaked lime, after which it is to be filtered and evaporated to the consistence of syrup. Alcohol is then to be added, and after another filtration by evaporation and cooling a crystallizable alkaloid is obtained, which is soluble in cold water, and more so in hot water; soluble also in alcohol, but not in ether nor the oils. Sulphuric acid gives it a fine red color. It is not precipitated by an infusion of galls, gelatine, bisulphate of alumina and potash, tartrate of antimony and potash, or acetate of lead. It does not saturate lime water. According to Gay Lussac and Pelouze, it is composed of 55.491 of carbon, 36.315 of oxygen, and 8.194 of hydrogen without any nitrogen, and accordingly it is not alkaline.

ALKALOID SALTS.

These salts, formed by the union of the vegetable principles we have just been considering, are like the principles themselves of interest chiefly to the medical practitioner. They are composed of four elements, and sometimes of five, as will be evident by the reflection that the same elements which enter into their own composition, enter also into that of the acid uniting with them, as in the acetate of morphia. Although oxygen, hydrogen, carbon, and nitrogen, constitute the morphia; yet the three first of these are also the constituents of acetic acid. The same remark would apply to the nitrate and muriate of morphia, but scarcely to the sulphate or the phosphate, although the oxygen of the acid is a element corresponding to one in the morphia, yet sulphur in the one case, and phosphorus in the other is superadded.

1655. ***Sulphate of morphia.***—Dissolve morphia in dilute sulphuric acid. It crystallizes in groups of acicular crystals; soluble in about twice their weight of water.

1656. ***Bisulphate of morphia.***—Dissolve the sulphate in excess of acid, afterwards digest the whole in ether, this will wash away the excess of acid and leave the bisulphate.

1657. ***Hydrochlorate of morphia.***—Put a few grains of morphia in a phial of hydrochloric acid gas, and shake them together until they combine together in crystals. An easier method is to dissolve the morphia in hot hydrochloric acid. The crystals are soluble in 20 times their weight of hot water.

1658. ***Nitrate of morphia.***—Add morphia to dilute nitric acid. The crystals are soluble in one and a half times their weight of water.

1659. ***Acetate of morphia.***—Dissolve morphia in acetic acid. It should be kept in solution, as when dried it becomes partially decomposed by the escape of a portion of its acid.

1660. ***Sulphate of cinchonia.***—Dissolve cinchonia in dilute sulphuric acid, evaporate and crystallize. This is soluble in less than its weight of water.

1661. ***Disulphate of cinchonia.***—Add an extra portion of cinchonia to a solution of the sulphate, and let it remain undisturbed for two or three days, a disulphate will be formed, which differs from the sulphate in requiring 60 times its weight of water for solution.

1662. ***Hydrochlorate of cinchonia***, procured in the same manner as the hydrochlorate of morphia.

1663. ***Nitrate of cinchonia.***—When very dilute nitric acid is saturated by cinchonia, a portion of the nitrate formed separates in the form of liquid globules, looking like oil, which in the course of a few days, become groups of acicular crystals. This property belongs also to quinia, and may serve to distinguish these from other alkaloids.

1664. ***Chlorate of cinchonia.***—Add chloric acid to cinchonia.

1665. ***Oxalate of cinchonia.***—Add oxalate of ammonia to a solution of the nitrate or sulphate of cinchonia. It falls down in the state of a white powder, dissolved with difficulty in cold or hot water, but soluble in hot alcohol.

1666. ***Acetate of cinchonia.***—Add acetic acid to cinchonia, the solution is always acid. This must be kept in solution, for when dried, it is decomposed into two salts, the superacetate which is soluble, and the subacetate which is insoluble.

1667. ***Sulphate of quinia.***—Dissolve quinia in sulphuric acid, or else soak some ***yellow*** Peruvian bark in sulphuric acid. This will dissolve the quinia and form the sulphate. If discolored by vegetable matter, animal charcoal is to be added to the solution. When colorless, it may be obtained in long acicular crystals, which are efflorescent in the air, of an intense bitter taste, and very little soluble in water. It possesses the curious property of becoming luminous when heated to about 212°, which phosphorescence is increased by friction. The above salt which is extensively used in medicine is a disulphate; to procure the neutral sulphate, its crystals must be rubbed in a mortar with dilute sulphuric acid—this is not phosphorescent like the disulphate, and is more soluble in water.

1668. *Hydrochlorate of quinia.*—Add quinia to hot hydrochloric acid. The crystals are more soluble than those of the sulphate.

1669. *Nitrate of quinia.*—Dissolve quinia in dilute nitric acid. See *Ex.* 1663.

1670. *Phosphate of quinia.*—Add phosphoric acid, mixed with water to quinia. The crystals are not soluble in water.

1671. *Oxalate and acetate of quinia.*—Add the alkaloid to the one or other acid as required.

DOUBLE SALTS.

It often happens that an acid will combine with two bases at the same time. Thus common alum is a combined sulphate of alumina and potass. Tartar emetic is a tartrate of antimony and potass. The double salts it is necessary for the young chemist to pay particular attention to, because they ordinarily interfere much with expected results from chemical combinations, and in testing the character of bodies, the presence of this second element much modifies the process to be performed, and the phenomena to be noted. The circumstance too of double combinations existing at the same time, renders it desirable to ascertain the absolute purity of the substances kept by the chemist, and to make the required tests by such a method as to ensure their single character. For example, common alum may be sufficiently pure for all purposes of the manufacturer, but if required in a state of absolute purity, it must be manufactured by adding the pure earth alumina washed from its potass, to equally pure sulphuric acid. Again, adding oxalic acid to copper an oxalate of the metal is formed; if we add ammonia to this, decomposition takes place, and oxalate of ammonia is formed, the oxyde of copper being precipitated. If instead of pure ammonia, we add an oxalate of ammonia to an oxalate of copper, no decomposition takes place, but a double salt, called oxalate of ammonia and copper, is the result: the oxalic acid in each salt is saturated previous to their mixture, and even when mixed, as there is no uncombined copper or ammonia present the mutual affinities of the bases for the acid are not disturbed. It may be thought that these double salts are but a mixture of the two single salts: in some instances they may be so but not in all, as in those last cited, the double salt is in rhomboidal blue crystals, the single salts are one in the state of flat prismatic white crystals, and the other in the form of a green powder. The prussiate of potass is a double salt of the cyanic acid, this acid combining both with iron and with potass; it forms lemon-colored crystals totally different in their characters from either the cyanide of iron or the cyanide of potassium, from the combination of which the prussiate or ferrocyanuret of potassium is composed. The number of constituents which are united to form a double salt are extremely varied. Thus the ferrocyanurets consist of four, iron, cyanogen, and the base. The platino-bichloride of potassium consists of only three, while numerous of them, particularly those in which ammonia forms a part, are frequently of five or even six elements.

THE FERROCYANURETS.

Ex. 1672. *Ferrocyanuret of potassium, ferrocyanate of potass, prussiate of potass.* (Fer + Cy 3 + P 2 = 186.) — This salt, so valuable as a test, is procured by boiling Prussian blue with potass. Decomposition takes place, the Prussian blue loses its blue color, and becomes of a slight yellow. It is crystallized by careful slow evaporation.

1673. *Second method.*—Add powdered Prussian blue, previously heated with dilute sulphuric acid, composed of 1 part of acid and 5 of water, to a hot solution of potass as long as its color is destroyed.

1674. *Third method.*—When required for the use of calico printers, it is recommended in Ure's "Dictionary of Chemistry," that this salt should be prepared by the following process, observing that the egg-shaped iron pot alluded to, and the manner of fixing it in the furnace, is represented beneath. "A shows the pot. E its contracted neck. I a cover to the same. This is made of cast iron, about 2 inches thick at the bottom and sides; this strength being requisite, because the chemical action of the materials wears the metal fast away. It should be built in the furnace in a direction sloping downwards, and have a strong knob B projecting from the back to support it upon the back wall, while its shoulder is embraced by the brick-work in front. The fire door F, and the ash-pit hole Z are placed in the back part of the furnace, in order that the workmen may not be incommoded by the heat. The smoke vent O issues from the arched top of the furnace towards the front. D is an iron or stone shelf, inserted before the mouth of the pot, to prevent loss in shovelling out the semi-fluid contents. The pot may be half filled with the materials.

"Into an egg-shaped iron pot, brought to moderate ignition, project a mixture of good pearl-ash and dry animal matters, of which hoofs and horns are best, in the proportion of 2 parts of the former to 5 of the latter. Stir them well with a flat iron paddle. The mixture, as it calcines, will gradually assume a pasty form, during which transition it must be tossed about with much manual labor and dexterity. When the conversion into a chemical compound is seen to be completed by the cessation of the fetid animal vapors, remove the pasty mass with an iron ladle.

"If this be thrown while hot into water, some of the prussic acid will be converted into ammonia, and of course the usual product diminished. Allow it to cool, dissolve it in water, .clarify the solution by filtration or subsidence, evaporate, and on cooling, yellow crystals of the ferroprussiate of potash will form. Separate these, redissolve them in hot water, and by allowing the solution to cool very slowly, larger and very regular crystals may be had. This salt is now manufactured in several parts of England on the large scale, and therefore the experimental chemist need not incur the trouble and nuisance of its preparation."

1675. *Ferroprussiate of soda, ferrocyanuret of soda.* (Fer 2 + Cy 3 + So 2.)—May be prepared from Prussian blue and pure soda by a similar process to that prescribed for the preceding salt. It crystallizes in 4-sided prisms, terminated by dihedral summits. The crystals are yellow, transparent, bitter in taste, and efflorescent. This salt is soluble in $4\frac{1}{2}$ times its weight of cold water.

1676. *Ferrocyanuret of barium.*—Mix together boiling hot solutions of 1 part of chloride of barium and 2 of crystals of pure ferrocyanuret of potassium. As the solution cools, small yellow rhomboidal crystals are deposited, and the mother liquor yields more by evaporation. The salt is not soluble in less than 1920 times its weight of cold water.

1677. *Ferrocyanuret of strontium.*—Boil Prussian blue in strontia water; then filter, evaporate, and cool the solution. The crystals deposited are yellow, and soluble in 4 parts of cold water.

1678. *Ferrocyanuret of calcium.*—Boil Prussian blue in lime water; then filter, evaporate, and cool the mixture. These crystals are also yellow and efflorescent.

1679. *Ferrocyanuret of magnesia* is obtained in like manner. Its crystals are deliquescent.

1680. *Ferrosesquicyanuret of potassium.* (Fer + 3 Cy + P $1\frac{1}{2}$ = 332.)—When chlorine is passed through a solution of ferrocyanuret of potassium till it ceases to precipitate Prussian blue from the *persalts* of iron, and the fluid is then filtered and slowly evaporated, it furnishes small prismatic crystals, which purified by a second solution assume a ruby red color. They require 3.8 parts of cold water for their solution, and are nearly insoluble in alcohol. Although this salt occasions no change in solutions of iron containing the peroxyde only, it is a most delicate test of the protoxyde of that metal.

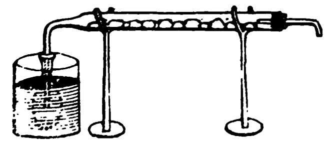
1681. *Ferrosesquicyanurets of barium, sodium, and calcium,* may be obtained by the same process, care being taken to avoid excess of chlorine, which is apt to re-act upon the salt.

1682. *Ammonio-sulphate of potass.*—Add ammonia to a solution of bisulphate of potash, or else mix together solutions of the sulphate of ammonia and the sulphate of potash. It forms upon evaporation transparent crystals of a bitter taste, and which contain equal portions of either sulphate, added to twice their aggregate weight of water.

1683. *Ammonio-sulphate of soda*, obtained in like manner, and very similar to the last. It contains more water in its crystals.

1684. *Ammonio-phosphate of soda, microcosmic salt, fusible salt, &c.*—Add 5 parts of crystallized phosphate of soda to 2 of crystallized phosphate of ammonia, dissolve them in water, then evaporate and crystallize. These crystals are so fusible that they are much used as a flux for metallurgical purposes. This salt is found abundantly in human urine. It consists of soda 1, ammonia 1, phosphoric acid 2, and water 10 atoms.

1685. *Ammonio-chloride of calcium.*—Pass a stream of ammoniacal gas through a tube containing the chloride of calcium, previously dried. Large quantities of the gas will be absorbed by the chloride, and the compound salt be obtained. As the absorption goes on, the chloride will swell, crack, and finally crumble into a fine powder, in the same manner as quick lime when water is added to it. Each grain of the chloride will absorb a cubic inch of ammonia. The following apparatus will show a convenient method of forming this and similar salts; the centre tube being connected at one end with a retort, in which the ammonia is liberated; and the other end with a bottle containing cold water and also surrounded by cold water, that the superflous gas may be collected and condensed.



1686. *Ammonio-nitrate of magnesia.*—Evaporate a mixed solution of the nitrates of ammonia and magnesia. It is soluble in 11 times its weight of water, and is less deliquescent than either of its constituent salts.

1687. *Ammonio-sulphate of magnesia.*—Mix together solutions of the two salts, or else add ammonia to a solution of the sulphate of magnesia. This occasions only a partial decomposition; some of the magnesia is thrown down, but the rest of it is still held in solution along with the ammonia. To obtain the salt required, filter the solution, and crystallize. It forms oblique rhombic prisms.

1688. *Ammonio-phosphate of magnesia*, is obtained by mixing strong and warm solutions of phosphate of ammonia and phosphate of magnesia. It precipitates in the form of a white crystalline powder, or in small 4-sided tasteless prisms, almost insoluble in water, but soluble in hydrochloric acid.

1689. *Ammonio-carbonate of magnesia.*—Mix excess of carbonate of ammonia with the chloride of magnesium. It forms very small crystals which are gradually deposited, and which are decomposed by hot water.

1690. *Ammonio-sulphate of manganese.* Add together solutions of the sulphates of ammonia and of manganese. Upon evaporation, the pale rose-colored crystals of this soluble salt will be deposited.

1691. *Ammonio-perchloride of iron, ens veneris, flores martiales.*—This is the yellow or red salt called in the Pharmacopœia, *ferrum ammoniacum*, and appears to be a mere mixture of ammonia with the perchloride of iron. It may be obtained by fusing together equal parts of the hydrochlorate of ammonia and the peroxyde of iron, subjecting the mixture to such a heat as that it shall be sublimated. The sublimate is the double or mixed salt required, and it will be found of a yellow, red or brown color, according to the relative proportion of the salt and oxyde. When the sublimate is dissolved, evaporated, and set aside to crystallize, it forms cubic ruby red crystals.

1692. *Ammonio-persulphate of iron.*—Mix together solutions of the sulphate of ammonia and persulphate of iron, the last being in excess. It crystallizes in colorless octohedra. When ammonia is added to a solution of the persulphate of the metal, the crystals formed are 6-sided and prismatic.

1693. *Ammonio-sulphate of zinc* obtained in like manner. It crystallizes in white rhomboids, which readily dissolve in water, and consist of 1 equivalent of each of the sulphates and 7 of water.

1694. *Ammonio-sulphate of nickel.*—Obtained in like manner; the crystals are 4-sided, of a green color, and soluble in 4 parts of water.

1695. *Ammonio-carbonate of nickel.*—Add carbonate of ammonia to carbonate of nickel, both mixed with water. This combination forms a salt which is very soluble.

1696. *Ammonio-sulphate of copper.*—Mix together solutions of the two sulphates. The crystals are of a dark blue color, and soluble in water.

1697. *Ammonio-persulphate of mercury.*—Add ammonia in excess to a solution of the persulphate of the metal. It is a white powder, soluble with great difficulty in water.

1698. *Sulphate of alumina and potass, common alum.*—Sulphate of alumina has a strong affinity for sulphate of potash, in consequence of which octohedral crystals of this double salt precipitate, whenever any salt of potash is added to a strong solution of sulphate of alumina. Alum is a salt of which large quantities are consumed in dyeing. It is prepared by several processes, as derived from different sources. It may be prepared by decomposing clay with sulphuric acid; the decomposition is effected in the most complete manner by calcining pure clay, grinding it afterwards to powder, and mixing it with 0.45 of sulphuric acid, of 1.45 density. This mixture is heated in a reverberatory furnace till the mass becomes very thick; afterwards left to itself for at least a month, and then treated with water to wash out the sulphate of alumina formed. The addition of sulphate of potash converts the last salt into alum.

1699. *Second method.*—But the mode of manufacture just described has not been found so advantageous as the following, which alone is practised in this country. A series of beds occur low in many of the coal measures, which contain much bisulphuret of iron. One of these, known as alum slate, is a siliceous clay, containing a considerable portion of coaly matter, and of the metallic sulphuret in a state of minute division. When this mineral is exposed to air and moisture it soon exfoliates, from the formation of sulphate of iron, the bisulphuret of iron absorbing oxygen like a pyrophorus. The excess of sulphuric acid formed attacks the other bases present, of which the most considerable is alumina. Aluminous schists often require to be moderately calcined or roasted, before they undergo this change in the atmosphere. The mineral being lixiviated, after a sufficient exposure affords a solution of sulphate of alumina and protosulphate of iron, from which the latter salt is first separated by crystallization. The subsequent addition of sulphate of potash to the liquor causes the formation of alum; the chloride of potassium answers the same purpose, and has the advantage over the sulphate that it converts the remaining sulphates of iron into chlorides, which are very soluble, and from which the alum is most easily separated by crystallization.

1700. *Third method.*—A very pure alum is obtained in the Roman States from alum-stone, which is simply heated till sulphurous acid begins to escape from it, and the residue of this calcination treated with water. This mineral contains an insoluble subsulphate of alumina with sulphate of potash. The heating has the effect of separating the excess of alumina, so that a neutral sulphate of alumina is formed. Alum-stone appears to be continually produced at the Solfatara, near Naples, and other volcanic districts, by the joint action of sulphurous acid and oxygen upon trachyte, a volcanic rock composed almost entirely of felspar.

1701. *Properties of.*—Alum requires 18.4 parts of cold and only 0.75 parts of boiling water to dissolve it, and crystallizes very readily in regular octohedrons, of which the apices are always more or less truncated, from the appearance of faces of the cube. The taste of alum is sweet and astringent, and its action decidedly acid; and it dissolves metals, with evolution of hydrogen, as readily as free sulphuric acid. The crystals effloresce slightly in air, and when heated melt in their water of crystallization, which amounts to 45.5 per cent. of their weight, or 24 atoms. The fused salt in losing this water becomes viscid, froths greatly, and forms a light porous mass, known as *burnt* alum.

1702. *Use as a mordant.*—If the quantity of carbonate of soda, necessary to neutralise a portion of alum, be divided into three equal portions, and added in a gradual manner to the aluminous solution, it will be found that the alumina at first precipitated is redissolved upon stirring, and that no permanent precipitate is produced till nearly 2 parts of alkaline carbonate are added. It is in the condition of this partially-neutralised solution that alum is generally applied as a mordant to cloth. Animal charcoal readily withdraws the excess of alumina from this solution, and so does vegetable fibre, probably from a similar attraction of surface. When this solution is concentrated by evaporation, alum crystallizes from it, generally in the cubic form, and the excess of alumina is precipitated.

1703. *Homberg's pyrophorus.*—A pyrophorus is formed from an intimate mixture of 3 parts of alum and 1 of sugar, which are first evaporated to dryness together, and then introduced into a small stoneware bottle; this is placed in a crucible, and surrounded with sand. The whole is heated to redness, till a blue flame appears at the mouth of the bottle, which is allowed to burn for a few minutes, and the mouth is then closed by a stopper of chalk. After cooling, the bottle is found to contain a black powder, which becomes red hot when exposed to air, and catches fire also, and burns with peculiar vivacity in oxygen gas. This property appears to depend upon the highly-divided state of sulphuret of potassium, which is intermixed with charcoal and sulphate of alumina. A pyrophorus can be produced from the sulphate of potash alone, without the sulphate of alumina, but it does not so certainly succeed.

1704. *Sulphate of alumina and ammonia.* $(S' + Al + N + Car.)$—Sulphate of ammonia may be substituted for sulphate of potash in this double salt, giving rise to ammoniacal alum, which agrees very closely in properties with potash alum.

1705. *Sulphate of alumina and soda.* $(S + O + Al + So.)$—Sulphate of alumina also combines with sulphate of soda, forming soda alum, which crystallizes in the same form as common alum. Crystals are obtained by mixing the constituent salts, and leaving a concentrated solution to spontaneous evaporation; or by pouring spirits of wine upon the surface of such a solution contained in a bottle, which deposits crystals as the alcohol gradually diffuses through it. This salt effloresces in air, as rapidly as sulphate of soda. It is very soluble in water, 10 parts of soda at 60° dissolving 11 parts of this salt.

1706. *Sulphate of alumina and protoxyde of iron*—Sulphate of alumina also combines with the sulphate of protoxyde of iron, when dissolved with that salt, and a considerable admixture of sulphuric acid. The double salt was found to contain 1 atom protosulphate of iron, 1 atom sulphate of alumina, and 24 atoms of water, which indicates a similarity in composition to alum. But it is deposited in long acicular crystals, which do not belong to the octohedral system, and has therefore no claim to be considered an alum. A similar salt with magnesia was obtained in the same way. Another combination of the same class, containing the sulphate of manganese, forms a white fibrous mineral, found in a cave upon Bushman's River, in South Africa.

1707. *Sulphate of potass and magnesia.*—Evaporate and crystallize a mixture of 2 parts of sulphate of potass and 1 of sulphate of magnesia. The crystals are rhomboidal and scarcely soluble.

1708. *Sulphate of soda and magnesia* obtained in like manner with the last, using the sulphate of soda. The crystals are truncated and rhombic, soluble in 3 times their weight of water.

1709. *Sulphate of potass and zinc.*—The crystals are soluble in 5 parts of water, and are made by evaporating the solution of the mixed sulphates.

1710. *Sulphate of potass and nickel.*—Add potass to the sulphate of nickel, filter, and evaporate. The crystals are green, of a rhomboidal form and sweetish bitter taste, soluble in 9 parts of cold water.

1711. *Sulphate of nickel and iron.*—Dissolve the mixed protoxydes in sulphuric acid, or what is a similar experiment, mix together solutions of the sulphates of each metal. This salt is green and efflorescent. It crystallizes in flat tables.

1712. *Sulphate of potass and copper.*—Digest peroxyde of copper in a solution of the bisulphate of potass. It is of a pale blue color.

1713. *Carbonate of potass and magnesia.*—"Add bicarbonate of potass in excess to a solution of the chloride of magnesia. No precipitation ensues, but in a few days crystals are formed, of an alkaline taste, which are decomposed by hot water. They may be regarded as a hydrated compound of 1 atom of bicarbonate of potass, and 2 atoms of carbonate of magnesia."—*Brande.*

1714. *Carbonate of soda and magnesia,* "is formed as the potassa salt, by carbonate of soda, but it is not so easily decomposed, and accordingly when magnesia is precipitated by excess of carbonate of soda, a portion of the soda salt is retained and not easily washed away."—*Brande.*

1715. *Protochloride of potassium and platinum, platino-protochloride of potassium.*—Dissolve in hydrochloric acid, the chloride of potassium and the protochloride of platinum, a double salt will be obtained, which solidifies in red 4-sided prisms, insoluble in alcohol. This salt is of 3 elements only.—Platinum 1, potassium 1, and chlorine 2, equivalent to 208.

1716. *Bichloride of platinum and ammonia, platino-bichloride of ammonia, ammonio-muriate of platinum.*—Mix together solutions of the hydrochlorate of ammonia and of the perchloride of platinum. A yellow powder falls down, which is the double bichloride required. It is but very sparingly soluble in cold water. If it assume a tawny or red appearance, it is because the rare metals iridium or palladium are present—these may be removed by boiling in dilute nitric acid and filtering the solution whilst hot. This salt consists of 4 elements,—hydrogen, chlorine, nitrogen, and platinum.

1717. *Bichloride of platinum and potassium, platino-bichloride of potassium.*—Mix together solutions of the chloride of potassium and of the bichloride of platinum. A yellow powder falls. It dissolves in water with difficulty.

1718. *Bichloride of platinum and sodium.*—Add chloride of sodium (common salt) to a solution of the bichloride of platinum, no precipitate will fall down, yet after two or three days if the liquor be allowed to evaporate, crystals will be formed of this salt.

They are of a prismatic or tabular form, of a deep orange-color, and soluble in both water and alcohol. The salt should be purified by dissolving it in alcohol, filtering, and evaporating. This solution will separate all the double protochloride, which as before observed is insoluble in this menstruum, and will consequently fall to the bottom.

1719. *Bichloride of platinum and barium.*—Add baryta water to a solution of bichloride of platinum, a precipitate falls composed of baryta and peroxyde of platinum. Crystals are deposited from the solution; this salt may also be obtained by mixing together the two chlorides in equal proportions. The crystals are orange-colored, and in form and appearance resemble those of the chromate of lead.

Note.—The bichlorides of numerous other metals with platinum have been obtained, such as those of strontium, magnesium, calcium, &c., but they are of little or no interest.

1720. *Tartrate of potass and ammonia.* (O. H. C + P.O + N + H.)—Add ammonia to a solution of cream of tartar in water. The double salt will be formed, it crystallizes in 4 and 6-sided prisms, very soluble in water and efflorescent, with the loss of ammonia in the air.

1721. *Tartrate of potass and soda.* (2Tar′ + Pot. + Sod.)—Instead of the ammonia of last experiment, use the carbonate of soda. The crystals are soluble in 5 times their weight of water, and constitute the well-known Rochelle salt, or sel de seignette of ancient pharmacy, and the *soda tartarizata* of the modern Pharmacopœia.

1722. *Tartrate of potass and lime.*—Add lime-water to a solution of supertartrate of potass till it begins to become turbid; in a few days acicular crystals of the salt are deposited, which effloresce when exposed to the air.

1723. *Tartrate of potass and iron.*—When 1 part of iron filings and 4 of tartar are digested together with water, a greenish astringent and difficultly-soluble salt is formed.

1724. *Pertartrate of potass and iron.*—Add peroxyde of iron to a solution of the bitartrate of potass. This dissolves in alcohol, but is not decomposed by the alkalis.

1725. *Tartrate of potass and copper.*—Boil together in water the oxyde of copper and cream of tartar. The solution yields blue crystals on evaporation, or if boiled to dryness forms the pigment called *Brunswick green.*

1726. *Tartrate of potass and lead,* obtained in like manner with the oxyde of lead. It is an insoluble white powder, not decomposed by the alkalis or by sulphuric acid.

1727. *Tartrate of potass and antimony, emetic tartar.*—This is usually obtained by boiling a solution of 100 parts of tartar with 100 parts of finely levigated glass of antimony (the protoxyde;) the ebullition should be continued for half an hour, and the filtered liquor evaporated to half its bulk, and set aside to crystallize; octohedral crystals of the emetic salt are thus obtained, and there is generally formed along with them a portion of tartrate of lime and potass, which is deposited in small radiated tufts, easily separated when the mass is dried. Emetic tartar is a white salt slightly efflorescent, soluble in about 14 parts of cold and 2 of boiling water.

1728. *Tartrate of potass and silver.*—Add tartar to nitrate of silver.

1729. *Tartrate of silver and antimony.*—Add nitrate of silver to a solution of emetic tartar. A nitrate of potass will be held in solution, while a double salt of tartaric acid with the silver and antimony will be precipitated as a white powder.

1730. *Oxalate of ammonia and potass.*—When the binoxalate of potassa is neutralized by an atom of ammonia, a double salt which forms long, permanent acicular crystals is obtained.

1731. *Oxalate of copper and ammonia.*—Digest oxalate of copper in a solution of the oxalate of ammonia, filter and evaporate, when rhomboidal crystals are deposited.

1732. *Oxalate of copper and potass,* is obtained by digesting carbonate of copper in a solution of bioxalate of potass. Prismatic and rhomboidal crystals are obtained, which Vogel considers as two distinct salts, the former consisting of 1 proportional of oxalate of copper, 1 of oxalate of potass, and 8 of water, and the latter of 1 proportional of oxalate of copper, 1 of oxalate of potass and 2 of water.

* * *

As we have now completed that extensive class of chemical substances known by the general name of salts, it is necessary, in addition to the introductory remarks appended to each division, to explain another arrangement of chemical bodies; lest the student consulting other works of chemistry, should find a disparity of nomenclature and arrangement, and being unable to reconcile the one with the other, his right understanding of the subject will be retarded. First, as to the terms binary, ternary, &c. We, pursuing the system recommended by most of our ablest chemists, have considered these terms as applicable to the number of *elements* composing a compound, but other chemists have considered the terms as having reference to the number of *atoms* of which such a body consists. We will illustrate this by the example of cyanogen, which consists of carbon 2 atoms, and nitrogen 1 atom. This, according to one system of classification would be binary, and according to the other ternary. In a body so little complex as cyanogen, the one designation appears as easy to remember as the other, but when numerous atoms are combined the case is much more difficult; for example, the alkaloids have from 20 to 30 atoms of various elements in their composition, yet each alkaloid is different from the others; to form appropriate designations for bodies of this kind, is therefore upon such a system highly inconvenient if not impossible. A second remark is called for in reference to nomenclature. Chemists (considering the *ultimate* elements of bodies) call the sulphurets, chlorides, phosphurets, carburets, oxydes, and all other substances, whether acid, alkaline, or neutral, which we have described between pages 86 and 146, binary *compounds.* Then considering the vegetable acids, they are called *ternary*, and the alkaloids *quaternary*, precisely as we have treated of them. In reference to salts a slight difference is observed, the *ultimate* elements constituting them are neglected, and their *proximate* principles only considered; thus instead of saying that the sulphate of zinc is a ternary compound, which it really is, it would be called a *binary* or *double salt:* its proximate principles being two, sulphuric acid and oxyde of zinc; thus—whether it be a salt of a mineral or vegetable acid, whether it be one of ammonia, or even one of an alkaloid, still it is but a double salt, containing one base and one acid. These being the least complex of saline combinations we have considered as *simple* salts. Also the salts which we have in p. 192, and following, called *double* salts, on account of their having a double base, are very often designated *triple* salts, there being three proximate elements, an acid, and two bases. It is immaterial which system we adopt, provided we understand the real composition of the bodies we have to operate upon.

ALCOHOL AND ETHERS.

We stated in p. 180, that, owing to excise regulations preventing the manufacture of alcohol on a small scale with economic advantage, it was not advisable to describe the process at full length; yet to pass it wholly unnoticed in a book of chemical manufacture would not be consistent with the importance of this fluid, especially as the making of it may be made a subject of direct class experiment. Alcohol, when perfectly pure and without water, consists of carbon 2 atoms, hydrogen 3, and oxygen 1. It cannot, however, be procured by any known artificial combination of these elements, but is solely the result of the vinous fermentation, sugar being by that natural process converted into alcohol, and this being separated from the fermented mass by the process of distillation. It is admitted that alcohol is occasionally found in fruits, particularly in the grape, but this is merely in consequence of an incipient fermentation taking place when the more saccharine fruits remain upon the trees until they are over-ripe. Whether it be possible for intoxication to ensue from eating such partially-fermented grapes is very problematical, notwithstanding so many Greek legends of Bacchus, Silenus, and other *anti-temperance* advocates of ancient days. Its union with the acids constituting *ethers* develop important chemical phenomena different from any which we have hitherto contemplated, and such as are of great interest and value. These compounds are all liquid, become gaseous at a very slight elevation of temperature, are powerful and pungent in odour, and of little specific gravity. Their general properties will be learnt by the following remarks and experiments.

Ex. 1733. *To procure alcohol.*—For the sake of experiment alcohol may be extracted from any fermented liquor, provided it shall have passed only a certain state of fermentation, such as porter, ale, cyder, wine, &c. It is only sufficient to put the liquid to be operated upon in a retort, and apply heat beneath. The spirit rises in steam, and this is condensed by cold, as explained beneath, and also in *Ex.* 160.

1734. *Process of the manufacture of alcohol.*—Previous to considering this process it is necessary to describe the still, or as it was once called, the alembic. B is the still itself, which is like a domestic copper with a contracted top, set in brick-work, and with a fire-place beneath. C is the head and neck of the still, which fits tightly on to the body of it. E is the end of the neck, where the body unites to the worm. F the worm tub, containing the worm or refrigerator. G the cock supplying cold water to condense with.

The process is as follows:—The fermented liquor is put into the vessel B, until about two-thirds full. The head is put on so as to unite well with the body, and also with the mouth of the worm. The joints being now luted with the lute, No. 1, *Ex.* 153. the fire is urged, until the contents of A nearly boil, which is known by a few drops passing from the worm. Great care is now requisite lest the still should boil over, or as it is technically called, should *run foul.* The fire being watched, the still will gradually become in a boiling state, and the steam pass more rapidly into the worm, and consequently the condensed spirit come more rapidly from the nose of it into the receiver placed beneath. The distiller now damps the fire somewhat, and opens the cock G, and which should have a pipe that leads to the *bottom* of the worm tub; thus supplying the worm tub with cold water. This when first admitted, plays against the bottom of the worm, cooling as much as possible the spirit as it passes out—becoming itself proportionably heated. Its specific gravity being thereby lessened, it ascends, cooling the worm it its progress upwards—for it will be remarked, that the cooling of the worm, and consequent heating of the water in contact with it, is gradually progressive; and as the spirit within is cold only when about to run away, so the water arrives at its full heat when at the top of the worm tub. In this heated state, the water, being no longer useful for condensation, passes off.

The trade of the spirit distiller is divided into two branches, the malt distiller and the rectifier. The business of the first is to make from grain, or other material, an impure spirit or whiskey, with which he supplies the rectifier. This person rectifies or purifies that which he receives, takes from it all smoky and empyreumatic taste, and renders it stronger if necessary.

The English malt distiller takes two quarters of barley and one of malt, which proportion varies according to circumstances, and mashes these up with water as a brewer does for the making of beer—no hops are added, nor is it afterwards boiled, but being cooled to about 70°, set at once to work. Fermentation soon ensues, the temperature rises to nearly 100°, and a spirituous liquid is formed more and more as the fermentation proceeds. It is suffered to go on till the liquid, or *must*, is on the point of turning sour; or in other words, until the vinous is about to change into the acetous fermentation; and this is a nice point for the practical distiller to determine. Should he stop the fermentation too soon, the whole spirit he might have obtained is not procured; if, on the other hand, he suffer it to proceed too far, part of the alcohol already formed will be changed to vinegar, and so lost. The point to which it may go with safety being determined, the must is taken up into the still at once, when the increased heat stops the fermentation; or if he should not be ready to distil it, he lets fall into the working tun a few drops of grease from a candle, which immediately stops all fermentation, and he may manage his affairs at more leisure. Were there not some method of at once stopping the action going on, the whole would often be spoiled, as even an hour will sometimes suffice to ruin a large quantity. Pearl-ash is sometimes used instead of tallow grease.

The must being pumped into the still, fire is placed beneath until it boils, when the spirituous part, about one-fifth of the whole, passes over through the worm, and is caught in cans, or conveyed by a trunk into vats. That which is left in the still after the first distillation is called *distiller's wash*, and is given to pigs, cows, &c., as a nourishing article of food.

The spirituous liquid procured by the first distillation is low in strength, and very disagreeable in flavor: it is called in this state *low wines*. This impure spirit is again put in the still, and distilled again, along with impure potass, called in the trade *grey salts*. The object of this is to retain the oil which occasioned the peculiar flavor of the low wines, forming with it a kind of soap which does not pass over in distillation. The produce then of this second operation, is not merely much stronger than before, but less nauseous; it is now called *malt spirit*, and is in a fit state to send to the rectifier—it is sold retail under the name of whiskey, but is infinitely inferior to that of Scotland or Ireland. If distilled without the salts, it would not be so tasteless as with them, still retaining the peculiar flavor of the ingredients employed, but purified from much that is sour, burnt, and obnoxious to the palate. Thus, if oats be employed instead of malt and barley, and submitted to the same process, but without the salts, it produces Scotch or Irish whiskey—if raisins be fermented and distilled the result is brandy—rice produces arrack—sugar, rum—and so on; the spirit having a particular taste according to the material from which it is made.

The rectifier merely carries on the process further, and by the same means. He places the *malt spirit* into his still, adds more grey salts, makes it boil, and condenses the vapor. The spirit is now still purer than before, yet not pure enough, except for common purposes, such as the making of very common goods: it is now called *rectified spirit*. It must be distilled a fourth time, but with white salts—that is with pearl-ash. This time it ought to be tasteless and exceedingly strong: it is now called *spirits of wine*. If required still stronger and purer, it must be submitted to distillation a fifth time, and passing over is called highly-rectified spirits of wine or alcohol, though it is not absolutely so, as a portion of water will still be attached to it. To deprive it of this, otherwise than by the above operation, is no part of the business of the distiller.

1735. *To procure alcohol without water.*—To prepare absolute alcohol, as it is termed when completely deprived of water, heat carbonate of potass to the temperature of 300°, and add it to spirit of wine in a glass-bottle. Shake the mixture well, and then allow it to remain at rest for some time. If a sufficient quantity of the alkaline carbonate has been added, the liquid divides into two parts; that which floats above is the alcohol, deprived of most of the water previously combined with it, while that below consists of the water which has dissolved the carbonate, and appears as a dense oily-looking fluid. The alcohol is decanted, or drawn off with a syphon, and more of the hot carbonate is added till it is no longer moistened. All the water having been removed in this manner, the liquid is then to be distilled with a gentle heat, to separate it from a small portion of potassa which it usually acquires from the salt employed. Nearly half a pound of the carbonate is required for every pint of rectified spirit of wine.

1736. *Second method.*—Other substances are occasionally employed to separate the water from the alcohol, as lime, baryta, and the chloride of calcium. Very strong alcohol may also be procured by suspending a bladder full of spirit of wine in the air; the water passes through the coats of the bladder, and evaporates from its surface, while the alcohol is retained. When several gallons of alcohol are to be freed from water, so as to procure it in a more concentrated state, though it may not be required in the form of absolute alcohol, this is frequently done by distilling it after mixing it with common salt.

1737. *Third method.*—Professor Graham's process for preparing absolute alcohol may be easily conducted by those who have an air-pump. A shallow glass or earthen basin is filled with quicklime in coarse powder or small fragments, and another nearly full of spirit of wine put over it. They are then placed on the plate of the air-pump, and the air is exhausted till the liquor appears as if it were beginning to boil. Both the water and alcohol evaporate at first, and the watery vapor is absorbed by the lime, which does not affect the vapor of the alcohol. But water does not remain in combination with alcohol, unless covered by an atmosphere of its own vapor; and as this is condensed by the lime as speedily as it is formed, the water continues to evaporate till it is completely removed, which usually requires three or four days, while the alcohol is prevented from evaporating by the pressure of its own vapor. Alcohol of specific gravity .796 may be procured in this manner.

1738. *Properties of.*—Alcohol is an agent that is constantly employed in the laboratory for affording a steady and powerful heat during its combustion, and in a great number of operations, where it is used as a solvent, or to afford peculiar combinations by the re-action of its elements with other substances. It is particularly useful in dissolving resins, camphor, volatile oils, vegetable acids and alkalis, and many salts and other substances which are insoluble in water, enabling us to separate them from other bodies with which they may be mixed or combined. From the large quantity of hydrogen and carbon which it contains, it has been occasionally employed to deoxidate some compounds, and from the rapidity with which it evaporates, it is sometimes used to produce cold.

Ether.—When mixtures of alcohol and the stronger acids are subjected to distillation, a liquid is formed, to which the term *ether* is applied, (or by the Germans, naphtha ;) and the nature and composition of which differs according to the acid employed ; in some cases containing the acid or its elements, and in others not containing them.

1739. *To prepare sulphuric ether.*—To prepare sulphuric ether, equal weights of sulphuric acid and alcohol are exposed to heat in a plain glass retort, pouring in the alcohol first and then the acid by a long glass funnel, and adjusting the retort in a sand-bath, already heated to the temperature of 200°. The acid and the alcohol should be well mixed by shaking them together in the retort, when the temperature rises considerably. The receiver should be tubulated to convey away the atmospheric air, and any other gaseous products that may be formed towards the close of the operation.

1740. Prepared in this manner it is not in a state of absolute purity, being combined with a small quantity of water. When required free from this, it must be mingled intimately with chloride of calcium, which retains the water ; and then be re-distilled.

In preparing ether on the small seale, an ounce or two of alcohol, with as much sulphuric acid by weight, will be sufficient to show the process, condensing the product in a common flask.

1741. *Properties of.*—Water can dissolve only a small quantity of ether, but alcohol and ether combine in every proportion. Ether is very inflammable, and burns with a much more copious and richer flame than alcohol ; the product of its combustion are water and carbonic acid. A few drops put into a detonating bottle full of oxygen gas, which is immediately corked, speedily diffuse themselves through the gas, and form an inflammable mixture that detonates violently on bringing a lighted match to the mouth of the bottle. This is an experiment that should be performed with a very small and strong bottle, as detonating bottles that have not been injured by any other explosive mixtures are frequently broken by this.

1742. *Cold produced.*—From the rapidity with which ether evaporates at natural temperatures, it is often used to produce an intense degree of cold. If a small quantity be poured into a jar, which is immediately covered with a tray, it speedily evaporates, and on applying a lighted candle to the mouth of the jar it is found to be full of an inflammable vapor.

1743. If a larger quantity of ether be put into an open jar, and a coil of thin platinum wire heated to redness in a spirit-lamp, be suspended over it at a particular distance, which is easily found on trying the experiment, instead of becoming cold it remains red hot till the whole of the ether is consumed.

1744. Sulphuric ether is not capable of dissolving so many substances as alcohol ; still however it is often found useful in separating or extracting principles that are insoluble in alcohol or water, more especially in vegetable chemistry. It combines with ammonia, camphor, resins, volatile oils, sulphur, phosphorus, and chloride of gold, but has little or no action on the fixed alkalis, earths, common metallic oxides, and the greater number of the salts.

1745. *Hyponitrous, nitrous, or nitric ether.*—In all experiments with nitric acid and alcohol, great care must be taken not to mix a large quantity of acid with the alcohol at once, as the gaseous products that are immediately produced are apt to throw out the whole of the mixture with explosive violence. The best method of preparing hyponitrous ether is by mixing equal weights of alcohol and the strong fuming acid, prepared by distillation from 2 parts by weight of sulphuric acid with 3 of nitre. The acid re-acts on the alcohol, and in a day or two it is converted into ether, which floats on the top of the remaining liquid, and may be easily removed by a small syphon.

1746. *Second method.*—Two or three ounces of alcohol are put into a bottle first, and small quantities of the acid are poured into it at a time by a funnel with a long stem, which passes to the bottom of the bottle, mixing them thoroughly after each addition of acid, and then placing the bottle in cold water to prevent any violent re-action taking place. A dram or two of the acid may be added every quarter of an hour in this manner till it is all mixed with the alcohol. The bottle should be provided with a conical stopple to allow the gas that accumulates to be discharged.

1747. *Third method.*—The Dublin College directs the alcohol to be mixed with sulphuric acid in a flask, and the mixture to be poured over bruised nitre in a retort. The proportions they recommend are nearly 865 of nitre, 1345 of sulphuric acid, and 725 of alcohol, by weight. The retort must be placed in a basin of cold water to prevent the action becoming too violent, and it should not be filled more than a third full of nitre.

1748. *Properties of.*—Hyponitrous ether always contains a little acid as it is procured at first, which may be removed by mixing it with a little potassa or lime, and then distilling it. It has a very pale lemon-color yellow, a pleasant smell similar to that of apples, and a strong penetrating taste. It is heavier and more volatile than sulphuric ether, burns with a lambent flame, and soon becomes acid on being kept. When it is purified by distillation, the operation should always be carried on with a very gentle heat, as it is decomposed when distilled quickly at a higher temperature.

1749. *Spirit of hyponitrous ether.*—This is familiarly termed *spirit of nitrous or of nitric ether, or sweet spirit of nitre,* and consists of hyponitrous ether and alcohol. It is prepared by mixing nitric or nitrous acid with a larger quantity of alcohol than is used in the process for preparing nitric ether, and distilling the mixture in a glass retort. The Edinburgh College directs 1 pound of nitrous acid to be mixed with 3 of alcohol, and distilled with a heat not exceeding 180°, till a quantity of liquid has been obtained equal to the alcohol employed. The distillation may be commenced whenever the materials have been mixed; the precautions already pointed out must be attended to, and the receiver kept cold in the usual manner. This compound is often prepared in large quantities by merely mingling hyponitrous ether and alcohol.

1750. *Acetic ether* is composed of 1 equivalent of sulphuric ether and 1 of acetic acid. It may be prepared by the action of aqueous sulphuric acid upon a mixture of alcohol and acetate of potassa, being separated by distillation from the sulphate of potassa formed at the same time. Liebig has procured it by distillation from the following materials mixed together,—4½ parts of alcohol, 5 of aqueous sulphuric acid, and 16 of acetate of lead, carefully freed from water of crystallization. Sulphate of lead remains in the retort.

Many other ethereal compounds have been prepared of late. They are usually procured by processes similar to those which have been described.

1751. *Oil of wine, or sulphate of ether,* is the name given to a compound of sulphuric acid and ether, which was formerly regarded as a compound of sulphuric acid and hydruret of carbon. It is prepared according to the formula of the London College in the following manner:—Mix carefully 2 pounds of rectified spirit with 4 pounds of aqueous sulphuric acid. Heat the mixture in a retort till it becomes black, and produces a black froth, allowing it then to cool by removing it immediately from the heat. It now presents a light fluid, resting uppermost, which must be carefully separated from another and heavier liquid upon which it floats. The lighter fluid must then be exposed to the air for from 10 or 20 hours, that any ether associated with it may be separated by evaporating; and after agitating it with a dilute solution of potassa to remove any sulphurous acid, the oil of wine subsides in a pure form. It has a yellowish color, a fragrant and penetrating odour, and a bitter taste. Water does not dissolve it, but it is soluble in alcohol and ether.

CHAP. VII.

CHEMICAL AFFINITY, ANALYSIS, TESTS, &c.

Bodies which unite together chemically do so in consequence of a certain and peculiar attraction which the one body has for the other. This is called *simple chemical affinity:* we have seen hundreds of examples of it in the preceding experiments, in the oxydes for example. Oxygen unites with all other bodies, and in exact proportion to the degree or power of its affinity, so will be the rapidity of the action which takes place. We know that gold combines with oxygen so slowly that its surface remains bright and untarnished for years—on the other hand, the metal potassium absorbs this gas so rapidly, that it soon crumbles to powder, or even bursts into flame. We have also had numerous occasions to observe that a second combination often takes place at the expense of the compound operated upon. In making tartaric acid and the carbonate of soda to form soda water a tartrate of soda is formed, and the carbonic acid escapes; this is because the tartaric acid has a greater affinity for the soda than the carbonic acid has, consequently the soda leaves the one acid, and combines with the other; and from the selection that bodies thus make when in union with two or more others this peculiar kind of attraction is called *elective* affinity. Sometimes, as we have already seen, an acid unites with two bases at once, such is an example of *double* affinity, and if we mix together two salts of such a nature that they mutually decompose each other, the action is said to arise from *double elective* or *compound* affinity. Thus, mix together solutions of carbonate of potass and sulphate of magnesia, both soluble compounds—a double decomposition will take place, and the bases will unite with each others acids, a sulphate of potass being held in solution, and the carbonate of magnesia falling down as a white powder. A consideration of the affinities of bodies, both in the nature and thê degree of such affinity, explains to us the reason why certain effects take place, and although to save space we have not explained the rationale of the various experiments heretofore recorded, yet the understanding all of them will be easy upon reference to the explanations given here, and to the tables of affinity, with the few experiments which immediately follow. The degree or amount of affinity which a body has for different others is extremely varied; thus sulphuric acid has a weak affinity for alumina, a stronger affinity for lime, a still stronger affinity for potass, and strongest of all for baryta. Thus a sulphate of alumina is decomposed by lime, potass, or baryta; but the sulphate of baryta is not decomposible by any other base. A similar instance of affinity is seen with potass. Carbonic acid and potass unite together more weakly than this alkali with the acetic acid, and this still less than with the hydrochloric, the nitric, or especially the sulphuric. The following experiments will show this very clearly:—

AFFINITIES OF POTASS.

Ex. 1752. *Acetic acid greater than carbonic.*—Put some carbonate of potass into a tumbler, and pour over it diluted acetic acid. (common distilled vinegar, which must previously be proved by barytes, to contain no sulphuric acid.) This acid will dissolve the potass and expel the carbonic acid with effervescence. The newly formed compound will be acetate of potass.

1753. *Hydrochloric greater than acetic.*—Into the newly formed solution of acetate of potass, pour some hydrochloric acid as long as an acetic smell arises from the tumbler; this smell will be occasioned by the expulsion and evolution of the acetic acid. The new compound will be chloride of potassium; this salt crystallizes in cubes, and is slightly deliquescent.

1754. *Nitric greater than hydrochloric.*—Into the solution of the salt of potass obtained in the last experiment pour some nitric acid; this will expel the hydrochloric acid, and a quantity of nitrate of potass will be held in solution. This salt may be crystallized: but the crystals are rather irregular, presenting a variety of forms.

1755. *Sulphuric greater than nitric.*—Into the solution of nitrate of potass obtained in the last experiment, pour some sulphuric acid; a solution of sulphate of potass will now be formed. This salt may be crystallized in six-sided prisms having pyramidal tops.

AFFINITIES OF SULPHURIC ACID.

1756. *Ammonia greater than iron.*—Prepare a solution of sulphate of iron in a tumbler, and drop into it as much ammonia as will precipitate the whole of the oxyde of iron. Here the superior affinity of sulphuric acid for ammonia is evident, and the new formed compound will be sulphate of ammonia, which crystallizes in six-sided prisms. If carbonate of ammonia has been used, the precipitate will, instead of the oxyde, be the carbonate of iron.

1757. *Magnesia greater than ammonia.*—Let the precipitate formed in the last experiment subside, and pour off the supernatant liquor into another clean tumbler. Now stir in the liquid as much carbonate of magnesia as will be dissolved. The preference of sulphuric acid for magnesia will be known by the discharge of carbonate of ammonia in the state of gas. Sulphate of magnesia will be held in solution.

1758. *Soda greater than magnesia.*—Into the newly-formed solution of sulphate of magnesia, pour a solution of carbonate of soda until the whole of the magnesia shall be precipitated in the state of a carbonate. The liquid will now be a solution of sulphate of soda.

1759. *Potass greater than soda.*—Into the solution of sulphate of soda now made, pour a solution of carbonate of potass, until effervescence just commences. Here the carbonic acid leaves the potass, and the soda combines with it; the soda thus receives a dose equivalent to what it lost to the magnesia, when poured into the solution of sulphate of magnesia.

1760. *Strontian greater than potass.*—Into the newly-formed solution of sulphate of potass pour a solution of pure strontia in cold water, or of carbonate of strontia in hot water; the sulphuric acid will now make another change, by leaving the potass and combining with the strontia, which compound, when cold, (if the solution has been hot) will be precipitated. When crystallized, sulphate of strontia takes the form of needles crossing each other.

1761. *Baryta greater than strontia.*—Dissolve the last-mentioned precipitate in boiling water, and pour in a solution of barytes, or chloride of barium. The sulphuric acid will now make one more election, seizing on the baryta, and forming with it a very insoluble salt, the sulphate of baryta.

Experiments like these might be instituted for every combining substance whatever, whether simple or binary, according to the degree of their attractive powers, but such would evidently occupy much space. The following order of affinities of the most common and important substances are therefore given, observing that the substance first named, unites most strongly with the body nearest to it in the list, and that consequently the addition of that one will at all times destroy the weaker affinities of the others. Thus in the list of acids given under potass, it will be found that sulphuric acid has a greater affinity for potass than any other acid has, and therefore if sulphuric acid be added to any neutral salt of potass with another acid, be it what it may, a sulphate of potass would be formed, and the other acid set at liberty, and so on for the rest throughout the list which follows:—

AFFINITIES OF ACIDS FOR BASES.

1762. *Sulphuric acid.*—Baryta, strontia, potass, soda, lime, magnesia, ammonia, alumina, metallic oxydes.

1763. *Sulphurous acid.*—Baryta, lime, potass, soda, strontia, magnesia, ammonia, alumina, metallic oxydes.

1764. *Nitric acid and nitrous acid.*—Baryta, potass, soda, strontia, lime, magnesia, ammonia, alumina, metallic oxydes.

1765. *Hydrochloric acid.*—Baryta, potass, soda, strontia, lime, ammonia, magnesia, alumina, metallic oxydes.

1766. *Phosphoric acid.*—Baryta, strontia, lime, potass, soda, ammonia, magnesia, alumina, metallic oxydes.

1767. *Phosphorous acid.*—Lime, baryta, strontia, potass, soda, magnesia, ammonia, alumina, metallic oxydes.

1768. *Boracic acid.* — Lime, baryta, strontia, magnesia, potass, soda, ammonia, alumina, metallic oxydes.

1769. *Carbonic acid.*—Baryta, strontia, lime, potass, soda, magnesia, ammonia, alumina, metallic oxydes.

1770. *Benzoic acid.* — White oxyde of arsenic, potass, soda, ammonia, baryta, lime, magnesia, alumina.

1771. *Oxalic acid, arsenic acid, fluoric acid, citric acid, tartaric acid.* — Lime, baryta, strontia, magnesia, potass, soda, ammonia, alumina, metallic oxydes.

AFFINITIES OF BASES FOR ACIDS.

1772. *Baryta.*—Sulphuric, oxalic, phosphoric, nitric, hydrochloric, tartaric, arsenic citric, benzoic, acetic, boracic, sulphurous, nitrous, carbonic, hydrocyanic.

1773. *Strontia.*— Sulphuric, phosphoric, oxalic, tartaric, fluoric, nitric, hydrochloric, boracic, acetic, nitrous, carbonic.

1774. *Potass and soda.*—Sulphuric, nitric, hydrochloric, phosphoric, oxalic, tartaric, arsenic, citric, benzoic, sulphurous, acetic, boracic, nitrous, carbonic, hydrocyanic.

1775. *Lime.*—Oxalic, sulphuric, tartaric, phosphoric, nitric, hydrochloric, arsenic, citric, malic, benzoic, boracic, sulphurous, acetic, nitrous, carbonic, hydrocyanic.

1776. *Magnesia.*—Oxalic, sulphuric, phosphoric, arsenic, nitric, hydrochloric, tartaric, citric, malic, benzoic, acetic, boracic, sulphurous, nitrous, carbonic, hydrocyanic.

1777. *Ammonia.*—Sulphuric, nitric, hydrochloric, phosphoric, fluoric, oxalic, tartaric, arsenic, citric, benzoic, sulphurous, acetic, boracic, nitrous, carbonic, hydrocyanic.

1778. *Alumina.*—Sulphuric, nitric, hydrochloric, oxalic, arsenic, fluoric, tartaric, citric, phosphoric, benzoic, acetic, boracic, sulphurous, nitrous, carbonic, hydrocyanic.

1779 *Oxyde of gold.*—Acids, gallic, hydrochloric, nitric, sulphuric, arsenic, &c.

1780. *Oxyde of silver.*—Gallic, hydrochloric, oxalic, sulphuric, phosphoric, sulphurous, nitric, arsenic, tartaric, citric, acetic, hydrocyanic, carbonic, ammonia.

1781. *Oxyde of platinum.*—The same as gold.

1782. *Oxyde of mercury.*—Gallic, hydrochloric, oxalic, phosphoric, sulphuric, tartaric, citric, malic, sulphurous, nitric, fluoric, acetic, benzoic, boracic, hydrocyanic, carbonic.

1783. *Oxyde of lead.*—Gallic, sulphuric, oxalic, arsenic, tartaric, phosphoric, hydrochloric, sulphurous, nitric, citric, malic, acetic, boracic, hydrocyanic, carbonic, fixed alkalis, fat oils, ammonia.

1784. *Oxyde of copper.*—Gallic, oxalic, tartaric, hydrochloric, sulphuric, nitric, arsenic, phosphoric, fluoric, citric, acetic, boracic, hydrocyanic, carbonic, potass, soda, ammonia, fat oils.

1785. *Oxyde of iron.*—Gallic, oxalic, tartaric, sulphuric, hydrochloric, nitric, phosphoric, arsenic, citric, acetic, boracic, hydrocyanic, carbonic.

1786. *Oxyde of tin.*—Gallic, tartaric, hydrochloric, sulphuric, oxalic, arsenic, phosphoric, nitric, citric, acetic, boracic, hydrocyanic, carbonic, the alkalis, &c.

1787. *Oxyde of bismuth.*—Oxalic, arsenic, tartaric, phosphoric, sulphuric, hydrochloric, nitric, citric, acetic, hydrocyanic, carbonic.

1788. *Oxyde of nickel and cobalt.*—Oxalic, hydrochloric, sulphuric, tartaric, nitric, phosphoric, citric, acetic, arsenic, boracic, hydrocyanic, carbonic.

1789. *Oxyde of zinc.*—Gallic, oxalic, sulphuric, hydrochloric, nitric, tartaric, phosphoric, citric, fluoric, arsenic, boracic, hydrocyanic, carbonic.

1790. *Oxyde of antimony.*—Gallic, hydrocyanic, benzoic, oxalic, sulphuric, nitric, tartaric, phosphoric, citric, arsenic, acetic, boracic, hydrocyanic, carbonic, sulphur, fixed alkalis, ammonia.

1791. *Oxyde of manganese.*—Oxalic, tartaric, citric, fluoric, phosphoric, nitric, sulphuric, hydrochloric, arsenic, acetic, hydrocyanic, carbonic.

1792. *Water.*—Potass, soda, ammonia, deliquescent salts, alcohol, carbonate of ammonia, ether, sulphuric acid, non-deliquescent salts. It is doubtful if sulphuric acid should not be placed higher on the list.

1793. *Sulphur.*—Oxygen, oxydes of lead; then in rotation, of tin, silver, mercury, arsenic, antimony, and iron; potash, soda, baryta, strontian, lime, magnesia, phosphorus, fat oils, ammonia, ether, hydrogen.

1794. *Alcohol.*—Water, ether, volatile oils, ammonia, fixed alkalis, alkaline sulphurets, sulphur, chlorides, phosphoric acid.

1795. *Ether.*—Alcohol, volatile oils, water, sulphur.

1796. *Saline sulphurets.*—Oxygen, oxydes of gold, silver, mercury, arsenic, antimony, bismuth, copper, tin, lead, nickel, cobalt, manganese, iron, other metallic oxydes, carbon, water, alcohol, and ether.

1797. *Sulphuretted hydrogen.*—Barytes, potass, soda, lime, ammonia, magnesia.

The above examples of affinity, which were first published by the celebrated chemist Bergmann, and by Dr. Young, communicate an immense mass of chemical information, and teach the probable result of any simple admixture of chemical ingredients, and the exact nature of the compound formed. Thus, in treating of the affinities of the bases for the acids, it will be seen that the lowest degree of affinity of a metallic neutral oxyde is with carbonic acid, therefore the carbonates of the metals are decomposed very readily, indeed by the admixture of any other acid whatever. While the gallates of the metals are fixed under most circumstances, with the alkaline bases a little difference is observed; for the carbonates, although holding together with little chemical adhesion, are yet more permanent than the cyanides of the same bases. This may be tried by adding hydrocyanic acid to the carbonate of potass—no effervescence ensues, but with carbonate of lead the carbonic acid flies off. Although this appears so plain and easy to understand, yet in practice it is often advisable, instead of adding a single body to a compound in order to decompose it, to use another salt of such a nature as to decompose the salt operated upon by double elective affinity; the process is thus more rapid and more decided, and the effect produced is rendered more evident to the senses. Suppose we wish to decompose a metallic salt, we need not search for an acid of greater affinity to add to it, but immediately use an alkaline carbonate. The alkali must have a greater affinity for the acid than the metallic oxyde has; consequently, an alkaline salt will be produced, and this being soluble will be suspended in the water used; the carbonic acid being freed will unite with the metal, and an insoluble carbonate of that metal will fall down; so also the chromates and the ferrocyanides of the metals are thrown down from their solutions by the chromate and the ferrocyanide of potassium with greatly more rapidity and perfection than by using the chromic or the hydrocyanic acid; a second and third example of double decomposition. The substances thrown down in circumstances of this kind are for the most part peculiar to the base employed, and thus by an examination of them we are enabled to detect the name and nature of the substance decomposed, even should we be previously unacquainted with it, and this which is called *chemical analysis* is one of the great divisions of the whole subject of chemistry.

CHEMICAL ANALYSIS is the art of finding the constituent principles of which any chemical compound is formed; this is done by means of what are called *tests* or *re-agents*, and which may be defined as those bodies that are used to examine and indicate by their action the peculiar properties of chemical matters. An acid turns a vegetable blue color into a red, therefore a blue vegetable color is a test for an acid. Turmeric paper is a test for an alkali, because when an alkali is applied to it such paper turns brown. The art of *analysis* or testing is one of extreme difficulty, and much must be left at all times to the chemist's knowledge and ingenuity. The following experiments and remarks will, it is hoped, much aid in the right understanding of this important part of study. The appearances put on by the bodies operated upon are the chief criteria by which we judge of their nature, therefore we may with the greatest propriety arrange and consider bodies to be tested under the popular heads of gaseous, liquid and solid at common temperatures, each class being divided into smaller groups as found afterwards requisite. Any other classification will however be equally convenient as that we have adopted with the compounds themselves in the preceding pages. The only object being to form bodies into classes,—those classes into sections, again into groups, and so on, according to the more or less compound nature of the material.

It is of the greatest necessity previous to the commencement of any operation of chemical analysis to ascertain the purity of the tests employed. These tests are some of them of such a nature, that impurity is of little consequence, or little likely to occur, such as litmus paper, turmeric paper, starch the test for iodine, gelatine a test for tannin, &c. Other tests which may be said to have a more chemical or rather a more compound character are sometimes purposely, and at others accidentally, contaminated with bodies whose presence would militate much against the result they are expected to occasion. The ordinary tests and their purification we will first consider.

Ex. 1798. *Turmeric paper, a test for alkalis.*—Powdered turmeric is yellow, and when boiled with water gives out its color; if therefore pieces of white paper be dipped in the decoction of turmeric they will imbibe the yellow dye. Paper thus dyed is cut up in narrow slips, and kept by the chemist as a test for alkalis; for if it be dipped into a solution of potass, soda, or ammonia, or exposed to the fumes of the latter, the yellow will change to a *brown* color; though dipped in a solution of a neutral salt, it will not be altered, nor yet by immersion in an acid, unless when it has been made brown by an alkali. In which case the acid neutralizing the alkali restores it again to the neutral yellow, when it becomes as serviceable as at first.

1799. *Litmus paper, a test for acids.*—Dilute with water the tincture of litmus, which is a liquid of an intensely blue color obtained from the archil weed, and dip slips of paper in the diluted liquid until they are dyed blue. Let these slips dry, and keep them in a dark place till wanted. If one of these slips be dipped into a solution, or exposed to the fumes of an acid, it will become red, and is therefore indicative of an acid. The action of an alkali is to restore its blue color, and in most cases to change it green, though this test of greenness is not so decided as that of turmeric paper. Hydrocyanic acid does not change the color of litmus; also, a more delicate test is found for certain of the acids in using the syrup of violets, or red cabbage water, in the flowers of the corn cockle, the blue iris, and the petals of the dark purple dahlias.

1800. *Sulphuric acid, to test the purity of.*—Add 4 or 5 times its weight of water to the acid; if pure there will be no sediment. If there should be one, it will most likely be the sulphate of lead, which is soluble in strong, but not in weak acid. In this case let the sediment subside, and filter the liquid, or decant it off for use; if wanted very strong it may be boiled until the water has evaporated. This boiling will also drive off any nitric or hydrochloric acid, should either be present, which the first is likely to be.

1801. *Hydrochloric acid, tests for the purity of.*—The impurities, if any, are likely to be iron, the sulphuric, and the sulphurous acids. To detect and purify it from the two first, see *Ex.* 863. To detect iron, let ammonia be added to it, until a neutral salt, the hydrochlorate of ammonia, is obtained. To this in solution add the hydrosulphuret of ammonia; if iron be present, the liqnid becomes black. Distillation purifies the acid from this contamination.

Nitric acid, tests for the purity of. See *Ex.* 797.

1802. *Oxalic acid, tests for the purity of.*—Put a little of the crystallized acid on the point of a knife, if it burns quite away without liquefying, and leaves no residue, it may be considered pure. If it leave a precipitate after burning, this may be considered either the bisulphate of potass, or the bitartrate of potass; to detect the first, add chloride of barium to throw down the white precipitate of the sulphate of barytes. To detect the last, boil it with sulphuric acid; if the bitartrate of potass be present, it will become dark colored, and give off sulphurous acid. If impure, it may be purified by re-dissolving and re-crystallizing.

1803. *Potass, to test the purity of.*—Caustic potass is often combined with the carbonic, sulphuric, or hydrochloric acids. To test for the carbonic acid, add another acid to it, (not the hydrocyanic,) and see if effervescence take place. To test for sulphuric acid, add the chloride of barium, and look for the usual white precipitate; and to test for the hydrochloric acid, add nitrate of silver; if the suspected acid be present, the white chloride of silver will be thrown down. It may also contain lime, if so add oxalic acid. This will seize the lime first, and precipitate the oxalate of lime. Carbonate of potass is for general purposes as useful as caustic potass.

1804. *Soda.*—The contaminations of soda are likely to be the same as those of potass, and of course may be tested for in the same manner.

Tests for oxygen, chlorine, nitrogen, iodine, and other simple bodies, are easily ascertained from a consideration of their properties, developed in the second and third chapter from pages 35 to 77. The compounds are more difficult to operate with.

General remark.—First add distilled water to the substance to be tested, which will of course show if it be soluble or not, and often lead the student to *guess* at its nature. Then let it be examined by dipping into the solution a piece of turmeric paper, and afterwards, if necessary, a piece of litmus paper; this will by showing if the body to be tested be alkaline, neutral or acid, much facilitate the future operations.

TESTS FOR THE ALKALIS.

Ex. 1805. Dissolve the substance in water, then add hydrochloric acid, which will dissolve or combine with the substance to be tested. Then add to it a solution of chloride of platinum, and to another portion of it a solution of sulphate of alumina. If *potass*, it will be rendered turbid by both—if *soda*, it will not be turbid by either.

1806. *Test for ammonia.*—This being the only liquid alkali, and having a strong scent, is immediately known. The salts of ammonia may be ascertained by adding quick lime to them; this uniting with the acid of the salt, liberates the ammonia, which is then distinguished by its peculiarly pungent odour.

TESTS FOR THE EARTHS.

Ex. 1807. Dissolve the substance in hydrochloric acid, then add oxalate of ammonia—an insoluble oxalate will fall down. If some time elapse before this takes place, the earth is magnesia if a white powder, or alumina if of a gelatinous substance. If the precipitate be immediate and white, it may be baryta, strontia, or lime; to ascertain which of these, take some of the original solution, and instead of oxalate of ammonia use strong oxalic acid only. This will occasion no precipitate if the body be baryta, but a white precipitate with the others, strontia and lime. Then add ammonia, if the precipitate be increased, it is lime; if not, strontia; or else add still more oxalic acid, this in excess will re-dissolve the oxalate of lime, but not that of strontia.

1808. *Other tests for baryta and strontia.*—Put a few particles of each earth into the flames of two candles, that with baryta will burn yellow, that with strontia red.

1809. Again, add to the solution of the earth excess of sulphate of soda, filter, test the clear liquor with carbonate of potass, if any precipitate falls it is strontia, if none, it is baryta.

1810. Again, add succinate of ammonia, if baryta be present it will be precipitated; if strontia there will be no precipitate.

1811. *To distinguish alumina from magnesia.*—When the chloride of these earths are added to the oxalate of ammonia, as recommended in *Ex.* 1807, unless the solution be of a particular strength, it may happen that no precipitate is formed. They may be detected otherwise, thus—Add to each a solution of the hydro-sulphuret of ammonia. If alumina be the earth it will be precipitated, but magnesia will not.

1812. *Another test for the same.*—Boil the earth itself in strong potass water; if alumina it will be dissolved, if magnesia not dissolved.

1813. *To separate lime from magnesia.*—Add to their solution in hydrochloric acid some bicarbonate of ammonia. The lime is thrown down in the state of carbonate of lime, but the magnesia is still held in solution by the excess of carbonic acid. The liquid is then to be filtered from the lime, and a saturated solution of phosphate of soda in excess to be added, and in a short time the ammonio-subphosphate of magnesia will fall down.

1814. *Another test for lime.*—Add to the solution of the chloride a few drops of the fluate of ammonia; if lime be present, a copious insoluble precipitate will fall down.

1815. *Test for silica.*—This is the only earth which will not dissolve in hydrochloric acid; therefore its presence is immediately ascertained by soaking it in that acid.

TESTS FOR THE METALS.

Ex. 1816. *General test for metals.*—Into any solution, where a metal is suspected to be in combination, pour a few drops of a solution of the ferrocyanide of potassium, (prussiate of potash,) stir the mixture. If a precipitate fall down, it is a proof of the presence of some metal, as the acid of this salt forms soluble salts with the alkalies and earths, but insoluble ones with the neutral metals. The color and quantity of the precipitate will serve with the assistance of other tests to demonstrate the name and nature of the metal.

1817. Mercury is the only metal fluid at ordinary temperatures that cannot be confounded therefore with any other. Potassium and sodium burst into flame when water is added to them, and as water produces an instantaneous effect upon no other metal, except perhaps the metals of the earths, none of which are easily procurable, or ever seen in a metallic state, they may be dismissed as known from the rest. Of the other metals first digest a piece of that whose name is to be ascertained in cold and weak sulphuric acid; if it dissolve and gives out hydrogen, it must be either iron, zinc, or manganese. If it will not dissolve in sulphuric acid, but is acted upon by nitric acid, so as to be changed into a white powder, insoluble in excess of acid, it is tin, antimony, or molybdena. If soluble only in aqua regia, and not in nitric acid, it is either gold, platinum, osmium, tungsten, or cerium. All the other metals are soluble in nitric acid; six of them, cobalt, palladium, uranium, copper, chromium, and nickel, giving colored solutions. In the following experiments we suppose the metal to be tested for to be in solution, and united with some acid, and consequently in the state of an oxyde or salt, and the means here adopted are understood to imply the detection of a metal under any ordinary circumstances of combination, except as an acid; also when several tests are recommended, each is to be added to a separate portion of the solution.

1818. *Tests for protoxyde of manganese.*—Add potass, or its carbonate or bicarbonate, the oxyde thrown down is white, becoming brown and black. Instead of potass add hydrosulphuret of ammonia, the precipitate is flesh colored, becoming black; with the oxalic acid, or the phosphate of soda, or the chloride of lime, also white.

1819. *Tests for peroxyde of manganese.*—This is greenish or brown with all the tests except with the alkaline sulphuret, by which it is precipitated like the protoxyde, flesh color, which however like that blackens by exposure.

1820. *Tests for protoxyde and peroxyde of iron.*—First add solution of galls, if there be a black precipitate it is the peroxyde, if no precipitate it is the protoxyde. If the yellow prussiate of potass (ferrocyanuret of potassium) be used, the peroxyde will be thrown down of a deep blue color, soluble in alkalis; the protoxyde, by the same test, shows a white precipitate which becomes blue. If the red prussiate of potass (ferrosesquicyanuret of potassium) be employed, the precipitate of the protoxyde will not be the deep blue, but white, (insoluble in alkalis ;) while it will have no effect upon the peroxyde or its salts. No other metal is thrown down of these colors by these re-agents, except that vanadium is rendered black by galls. The prussiates are sure tests for iron at all times.

1821. *Tests for zinc.*—All the tests, except the red prussiate and the chromate of potass, throw down white precipitates. These salts produce the last a yellow—the other a yellowish red, soluble in hydrochloric acid.

1822. *Tests for protoxyde of tin.*—White is the color of the precipitate by an alkali ; brown by sulphuretted hydrogen ; white by oxalic acid. Being stirred by a rod of zinc metallic tin precipitates. Iodide of potassium gives a yellowish white, and the chloride of gold a deep purple.

1823. *Tests for peroxyde of tin.*—Tin is precipitated white by an alkali ; yellow by sulphuretted hydrogen. White but not metallic by a bar of metallic zinc. No precipitate with iodide of potassium or with the chloride of gold.

1824. *Tests for cobalt.*—Cobalt is precipitated of a violet blue by potass ; red by its carbonates. Green by the yellow prussiate of potass. Brownish by the red prussiate. Black by an alkaline sulphuret. Grey by chromate of potass.

1825. *Tests for nickel.*—This metal is precipitated apple green by alkalis. Greenish white by yellow prussiate of potass. Yellowish green by the red prussiate. Black by the hydrosulphuret of ammonia. Light green by phosphate of soda. Chromate of potass gives a very deliquescent red salt, from which the alkalies deposit an orange sediment.

1826. *Tests for copper.*—Add ammonia in excess ; the oxyde of copper, if present, is dissolved, and a bright blue clear and transparent color is obtained. A plate of bright iron immersed in the solution becomes covered with a film of metallic copper.

1827. *Test for the suboxyde of copper.*—Potass precipitates it white, (afterwards becoming black ;) the carbonate of potass yellow ; the bicarbonate also yellow. Red prussiate of potass red brown. Phosphate of soda white, becoming blue.

1828. *Test for the protoxyde of copper.*—Potass precipitates it blue ; its carbonate blue—its bicarbonate green. Red prussiate of potass yellowish green, and phosphate of soda greenish white ; different in every respect from the suboxyde. They are both thrown down black by sulphuret of ammonia. All the solutions of copper are blue or greenish blue.

1829. *Tests for lead.*—Add to its solution any alkali or alkaline carbonate, sulphuric, or oxalic acid, or the yellow prussiate of potass ; the precipitates are all white. With sulphuretted hydrogen, or an alkaline hydrosulphuret it is black ; with iodide of potassium yellow ; with chromate of potass yellow, which is soluble in potass. Stirred with a bar of metallic zinc, the lead is deposited on the zinc in a bright metallic crust. Solution of galls white.

1830. *Tests for antimony.*—The deposit is white with the alkalis or their carbonates, but it is deep red or orange with sulphuretted hydrogen, and the hydrosulphuret of ammonia. A bar of zinc deposits a black powder of metallic antimony. Chromate of potass produces a brown ; solution of galls a white or straw color.

1831. *Tests for bismuth.*—The neutral salts of bismuth are decomposed by the addition of water, white powdery sub-salts being thrown down. By most tests the oxyde is thrown down white, like numerous others of the softer and more fusible metals. The following will, however, serve to distinguish it from them. Sulphuretted hydrogen and the hydrosulphuret of ammonia throw it down black or deep brown ; it therefore differs from zinc and antimony. The precipitate with the iodide of potassium is brown, whereby it differs from mercury, lead, silver. and tin. It is also thrown down as a lemon-colored powder by the chromate of potass—lighter colored than any other metallic chromate, except those of zinc and platinum. A rod of zinc throws down a black powder.

Tests for arsenic. See *Tests for Acids.*

Tests for chromium. See *Tests for Acids.*

1832. *Tests for suboxyde of mercury.*—Potass throws the suboxyde of mercury down black, insoluble in excess of potass. Carbonate of potass yellow ; bicarbonate of potass white. Ammonia black, insoluble in excess. Red prussiate of potass reddish brown. Sulphuret of ammonia and sulphuretted hydrogen black. Iodide of potassium greenish yellow, becoming black.

1833. *Tests for protoxyde of mercury.*—Potass produces a yellow; its carbonate a reddish brown—its bicarbonate the same. The red precipitate of potass a yellow. Iodide of potassium first yellow, then scarlet. This fine color is alone sufficient to show the metal to be mercury, and its combination that of the protoxyde. *Note.* The red prussiate of potass does not act upon the chloride of mercury.

1834. *Tests for silver.*—The oxyde thrown down by potass is brown; by its carbonates white; by ammonia brown and very soluble; yellow prussiate of potass white; red prussiate of potass reddish brown; iodide of potassium yellowish white. The chromate of potass produces a crimson color. A rod of iron, tin, lead, copper, zinc, bismuth, or antimony, precipitate metallic silver; but the most characteristic test is to add hydrochloric acid, or a chloride of an alkali, to a salt of silver; this will throw down a copious white precipitate, which is soluble in ammonia, and insoluble in nitric acid, and which becomes black by exposure to the light.

1835. *Tests for gold.*—Add potass to try the oxyde; this is an imperfect black. Ammonia or its carbonate in excess give it a yellow tint. The yellow prussiate of potass produces a reddish brown. The red prussiate a yellowish green; the same with the iodide of potassium. But the best tests are the protochloride of tin, which gives a purple precipitate, and the protosulphate of iron, which throws down metallic gold; also the protonitrate of mercury yields a black precipitate.

1836. *Tests for platinum.*—Potass and ammonia, and their carbonates, produce a pale yellow oxyde. The hydro-sulphurets a black or brown. Iodide of potassium also a brown. The precipitate from potass is insoluble in hydrochloric acid, but soluble in excess of potass, if hot; that also thrown down by ammonia is soluble in excess, if hot; but not soluble in the other alkalis. By this the metal may be known; and also by the carbonate of soda not producing the same effect as the carbonate of potass: viz. a yellow precipitate.

The other metals, being of rare occurrence, and not having been previously described, the tests for them need not be given.

TESTS FOR THE ACIDS.

Ex. 1837. *Tests for chloric acid.*—As this acid is never found in nature, and is rare except combined with an alkali; we refer for its tests to the chlorates. The acid itself never decomposes a metallic salt, except it be a carbonate, and then assisted by heat in separating the carbonic acid. It has no action on sulphate of indigo, is decomposed by sulphuretted hydrogen, and by the hydrochloric and sulphurous acids, but not by the nitric.

1838. *Tests for perchloric acid.*—This cannot exist except united to a base; it differs from the last in not being decomposed by the hydrochloric or sulphurous acids. And its alkaline salts are not decomposable by the most powerful acids. It occasions white precipitates in strong solutions of all the salts of potass.

1839. *Tests for iodic acid.*—Add sulphuretted hydrogen or sulphurous acid, this will decompose the iodic acid and liberate free iodine. This is detected by the blue color which is seen when starch is added. Sulphuric acid has no effect.

1840. *Tests for nitrous acid.*—This acid is very marked by its orange-colored fumes, and by not dissolving gold when united to hydrochloric acid.

1841. *Test for nitric acid.*—Put a drop or two of the acid upon copper, if nitric acid, it will give off fumes of nitrous acid gas from its action upon the copper. If the acid be very much diluted, it is necessary to apply heat. When added to hydrochloric acid it dissolves gold. It bleaches indigo if hot.

1842. *Test for hyposulphurous acid.*—A white precipitate is caused by acetate of lead. A white, which afterwards becomes black by nitrate of silver; a black by the protonitrate of mercury; and when strong sulphuric acid is added to it, sulphurous acid is disengaged and sulphur deposited.

1843. *Tests for hyposulphuric acid.*—No precipitate is occasioned by acetate of lead, nitrate of silver, or protonitrate or mercury. When strong sulphuric acid or hydrochloric acid is mixed with it, sulphurous acid is disengaged, and sulphuric acid is left, but no deposition of sulphur.

1844. *Tests for sulphurous acid.*—This is known from the next acid by its action on iodic acid, for which see *Ex.* 1839, and in its union with barytes, being soluble in excess of the acid while cold.

1845. *Tests for sulphuric acid.*—Add to the dilute acid, any soluble salt of barytes, a dense white precipitate, insoluble while cold, in its own or any other acid will sufficiently distinguish the present.

1846. *Test for phosphorous acid.*—Add nitrate of silver, and the result is a brown powder of reduced silver; or else add protonitrate of mercury, and the result is a grey powder of reduced mercury.

1847. *Test for phosphoric acid.*—Add nitrate of silver, and the result is a yellow powder, soluble in nitric acid, and in ammonia; add protonitrate of mercury, and the result is a white powder, soluble in nitric acid.

Test for carbonic acid. See *Test for Gases and for Carbonates.*

1848. *Test for manganesic acid.*—This added to potass produces a salt of a light green color, and possessing very [peculiar properties. See *Ex.* 1421.

1849. *Test for boracic acid.*—This acid is at once known by its occasioning the paper of turmeric to turn of a *brown* color, in the same manner as an alkali. When litmus paper is used it turns it of a dark red, like port wine, not of the fine red which other acids produce. It tinges the flame of alcohol of a fine green color.

1850. *Test for arsenious acid.* — Pass through the solution of arsenious acid a little sulphuretted hydrogen. The sulphur of the gas combines with the metallic arsenic, rendering the liquid of a yellow color, while the hydrogen combines with the oxygen of the arsenious acid, forming water.

1851. *Second test for ditto.*—Put a few drops of the solution of arsenious acid in water into an ounce or two of water, and add a small quantity of a solution of the sulphate, nitrate, or acetate of copper. The liquid remains quite transparent and colorless, the arsenious acid not having so great an affinity for the oxyde of copper as the acid with which it is already combined. If a small quantity of an alkaline solution (potassa or its carbonate) be now added, the alkali will unite with the acid of the salt employed, and remain in solution, and the arsenious acid combining with the oxyde of copper will form arsenite of copper, which is insoluble in water, and is precipitated of a grass-green color.

1852. *Third test for ditto.*—Drop a solution of nitrate of silver into a solution of arsenious acid in distilled water. No precipitate is thrown down, nitric acid having a stronger affinity for oxyde of silver than arsenious acid. If a little potassa be now added, it combines with the nitric acid and forms nitrate of potassa, which remains in solution; and the arsenious acid, combining with the oxyde, forms a yellow-colored precipitate—the arsenite of silver.

1853. Add a solution of the nitrate of silver to a solution of phosphate of soda. Phosphate of silver is precipitated of a yellow color, and nitrate of soda remains in solution. The nitrate of silver, cannot, therefore, be used as a test of the presence of arsenious acid in solutions which may be suspected to contain phosphate of soda, as in liquids obtained from the stomach of an invidual supposed to be poisoned by arsenic. The precipitate of the phosphate is smooth and uniform; that of the arsenite, curdy.

1854. Prepare a solution of the ammoniaco-nitrate of silver, by adding ammonia in small quantities at a time to a solution of the nitrate of silver, proceeding in the same manner as in the preparation of ammoniaco-nitrate of copper. Then drop a little into a very diluted solution of arsenious acid; the ammonia remains in combination with the nitric acid, and the arsenious acid, combining with the oxyde, gives the characteristic yellow-colored precipitate of arsenite of silver.

1855. If the ammoniaco-nitrate be mixed with a solution of the phosphate of soda, a white precipitate will be thrown down, instead of the yellow-colored precipitate which the nitrate of silver gives with a solution of this salt; and accordingly the ammoniaco-nitrate of silver is always preferred to the nitrate in testing any liquid for the presence of this poison.

1856. Precipitate some arsenite of silver from a solution of arsenious acid by the ammoniaco-nitrate of silver; diffuse the precipitate through the liquid, divide it into two portions, and add ammonia to one and nitric acid to the other; both will be re-dissolved, and accordingly great care must be taken to have no excess either of acid or alkali in using the nitrate of silver as a test of the presence of arsenious acid, even though a considerable quantity of arsenious acid should exist in solution.

1857. The test with silver is often very obscure when organic matters or common salt happen to be present in the solution. The color of the precipitate is modified, or it does not appear at all. Alone, it cannot be regarded as a certain test of the presence of arsenic in a mixed liquid.

1858. Mix some lime water with a small quantity of a solution of arsenious acid; arsenite of lime is immediately precipitated in the form of a white powder. Add arsenious acid in excess to the precipitated arsenite of lime: it is soon dissolved. This does not distinguish arsenious acid from oxalic acid.

1859. Put a few drops of a solution of the bichromate of potassa into a solution of arsenious acid. The liquid assumes a rich pea-green color after standing for some time, heat a little of it by a spirit lamp, and the green color is developed immediately. The change of color is owing to the arsenious acid attracting oxygen from part of the chromic acid, and converting it into oxyde of chrome.

1860. Drop a little of the solution of bichromate of potassa into a solution of tartar emetic; the liquid assumes the same green color as in the preceding experiment, a circumstance that was pointed out by Mr. Lawrence Reid; and accordingly the bichromate of potassa cannot be used as a test for arsenic in any solution which may be suspected to contain tartar emetic. Many deoxidating agents produce a similar effect.

1861. *Test for antimonious acid and antimonic acid.*—These are known from other acids by being decomposed by sulphuretted hydrogen and hydro-sulphuret of ammonia of a yellow color. They are known from each other by the first being white; the other acid straw color. They are both solid and insoluble in water, or nearly so. The antimonic acid is decomposed by heat; the antimonious not decomposed, but volatized.

1862. *Test for chromic acid.*—Its bluish purple color is sufficient to distinguish this acid, and also its forming transparent crystallizable yellow salts with the alkalis, and mostly beautifully-colored powders when added to the salts of the metals. It also dissolves gold when added to hydrochloric acid. This is the only acid which forms a yellow salt with potass.

1863. *Test for hydrochloric acid.*—Add nitrate of silver; if hydrochloric acid be present, a curdy white precipitate, insoluble in nitric acid, but soluble in ammonia, falls down; or else you may add ammonia, which will throw down a white powder. (See also *Tests for Gases.*) Its strong and peculiar scent is also characteristic.

1864. *Test for hydrobromic and bromic acid.*—When strong sulphuric acid is added, bromine is evolved, and the solution becomes yellow. See also *Ex.* 882.

1865. *Test for hydrofluoric acid.*—Pour a drop on a piece of glass, or let a piece of glass be exposed to its fumes, when in either case it will be corroded. Little or no difficulty can arise in telling this acid in a free state, as it cannot be kept in a glass vessel; so also a fluate is easily known by the action of sulphuric acid upon it. See *Ex.* 883 and 884.

1866. *Test for tartaric acid.*—Add potass, which uniting with it will form the supertartrate of potass, or cream of tartar, which will fall as a gritty white powder, which is soluble in alkalis and hydrochloric acid. Added to the nitrate of lime, the precipitate is white, and nearly insoluble in water, but soluble in dilute acid. See also *Ex.* 1502.

1867. *Test for oxalic acid.*—This is the only acid which will decompose sulphate of lime, the oxalate of lime formed becoming dissolved in excess of the oxalic acid; from this solubility the oxalic is known from the tartaric acid.

1868. *Test for citric acid.*—Add to its solution an acetate of lead; wash the precipitate, and if this will dissolve in ammonia, it is known to be the citrate of lead, and consequently the acid tested will be the citric acid. Its union with lime is slightly soluble in water, and much more so its salt with potass.

1869. *Test for acetic acid.*—Vinegar is too well known to need testing. Its compounds, the acetates, are decomposed by sulphuric acid, which liberating the acetic acid, at once indicates its presence by pungent fumes.

1870. *Test for gallic acid.*—This is at once indicated by producing a black purplish color with solutions of the protosalts of iron and the salts of vanadium, which is not the case with any other acid. Infusion of galls only produces this effect from its containing this acid.

1871. *Test for tannin or tannic acid.*—Pour a few drops of the solution of the protochloride of tin into a wine-glass containing a fresh made infusion of nut galls, or of oak bark. The precipitate will be insoluble.

1872. The best test however is gelatine. When tannin is suspected to exist in any vegetable, make a decoction or infusion of it, and into half a wine glass-full, drop some solution of isinglass, size, or glue. If tannin be present, a white or yellowish flocculent precipitate will instantly take place. On the other hand, an infusion of nut galls or oak bark will discover the presence of gelatine, in any mixture where it may exist.

Note.—It is on this principle that leather is tanned, the raw hides contain gelatine, and the oak bark tannin; and when the hides are immersed in pits containing the bark liquor, their fibres are brought into closer contact, and the tannin deposited in their pores, and of course their texture is thus rendered tougher and stronger.

1873. *Test for hydrocyanic acid.*—The scent of peach kernels is given off by this acid so strongly that it cannot be mistaken for any other. It also produces a blue color by mixture with the salts of iron.

TESTS FOR SALTS, ETC.

As all salts are combinations of acids with various bases, the experiments indicative of the various bases and acids will detect the constituents of the salts which they form; yet, notwithstanding this the various classes of salts have certain characters peculiar to themselves, a knowledge of which will materially shorten investigation. The following remarks may therefore be useful.

*Ex.*1874. *To detect the sulphates.*—All the sulphates, except that of baryta, are decomposed by adding to their solution, chloride of barium, to throw down a white powder; but there are some sulphates which are insoluble in water, and consequently are already a white powder; therefore adding this chloride, will only substitute one white powder for another. To decompose these insoluble sulphates, they must be fused with carbonate of soda, which forms a carbonate of the metal and a sulphate of soda, the last may be washed away, and the carbonate left be tested for the base. This is the only way of decomposing sulphate of baryta.

1875. *To detect the chlorates and chlorides.*—All the chlorates are decomposed by heat with explosion, forming chlorides. The chlorides are soluble or insoluble. They are known by the action of sulphuric acid upon them, this with very few exceptions liberating hydrochloric acid. Also all the soluble chlorides throw down a white precipitate when solution of nitrate of silver is added to them, which precipitate is soluble in ammonia. Many of the saturated solutions of the chlorides become milky when diluted with water, a subchloride being formed. See also *Ex.* 1167.

1876. *Tests for the iodides and iodates.*—The iodates like the chlorates explode with violence when thrown upon red hot charcoal. They are at once known by adding starch to their solutions. This throws down the iodide of starch which is of a fine blue color. When heated, the iodides give out a purple gas of iodine. They are all decomposed by sulphuric, and nitric acids, or by chlorine.

1877. *Tests for the nitrates.*—These are all decomposed by heat and by sulphuric acid, and all soluble in water. A protosulphate of iron with excess of acid being heated with any nitrate, casts down a dark brown precipitate. The nitrites, except perhaps that of lime, *Ex.* 1240, are not permanent salts.

1878. *Tests for the hypophosphites, phosphites, and phosphates.*—The first two of these classes smell of phosphorus, and when heated, give off phosphorus or phosphuretted hydrogen. The phosphates of the alkalis are soluble in water, those of the earths and metals mostly insoluble. They are decomposed by boiling with potass, and are soluble in nitric and hydrochloric acids.

1879. *Tests for the carbonates.*—No salts are more easy to detect than these, as the addition of any strong acid to them, except the hydrocyanic in certain cases, will decompose them with effervescence. Heat also generally decomposes them, driving off carbonic acid. They are mostly insoluble, yet that of potass is one of the most soluble salts known.

1880. *Tests for the borates.* See *Borates*, p. 166.—They are all decomposed by the addition of sulphuric, nitric, and hydrochloric acid.

Tests for the arseniates, arsenites, antimoniates, &c. See *Tests for Poisons.*

1881. *Tests for the chromates.*—These are known from their color, and if metallic, by being also insoluble, except one or two. See *Chromates*, p. 169.

1882. *Tests for the cyanides and acetates.*—These like the carbonates are decomposed by the stronger acids, but not with effervescence, besides which, when thus decomposed, both the acetates and cyanides emit the smell of their peculiar acids; one being pungent like strong vinegar, the other sweet like the kernels of stone fruit. The cyanates are decomposed by the addition of water only—the cyanic acid changing into carbonic acid and ammonia.

1883. *Test for the tartrates.*—Add potass to any salt supposed to be a tartrate. This will decompose any tartrate, except of course that of potassa, and throw down a gritty, nearly insoluble powder. It is so rare for a salt of potass to take this character that it cannot be mistaken.

1884. *Test for the oxalates.*—All these, except the oxalate of lime, are decomposed by adding lime to their solutions. This earth throws down a precipitate at first, but which is afterwards dissolved in excess of acid. The only difficulty then arises is decomposing the oxalate of lime, and which may exist in the state of a solution in the acid, and as an insoluble powder. First, try if free acid be present by litmus paper; if found saturate it by lime, until the litmus paper is no longer changed to a red. We shall now have an oxalate of lime as a powder; this being put into a crucible, and made red hot, is changed into chalk, or the carbonate of lime, which may be tested as before recommended.

TESTS FOR THE GASES.

There has been already so much said upon the peculiarities of the various gases, that tests for each would but be a repetition of former experiments. We shall in this place merely give directions how to analyze an unknown gas or mixture of gases. We will suppose that the gases are in a dry state, and contained in a jar opening at the top, yet as many gases are lighter than atmospheric air, and would consequently soon escape upon opening such a vessel, it is to be understood that the experiments upon them are to be conducted quickly.

1885. *Gases absorbed by water.*—First add a little water to the jar of gas, and see if the contents are absorbed by the water; if so the gas is either 1 Chlorine, 2 Euchlorine, 3 The peroxyde of chlorine, 4 Nitrous oxyde, 5 Ammoniacal gas, 6 Nitrous acid gas, 7 Sulphurous acid gas, 8 Hydrochloric acid gas, 9 Hydriodic acid gas, 10 Hydrobromic acid gas, 11 Hydrofluoric acid gas, 12 Sulphuretted hydrogen, 13 Cyanogen, 14 Carbonic acid, (Arsenuretted hydrogen is partly soluble.) The tests for Nos. 6, 7, 8, 9, 10, and 11, being now acids, have been already given. Of the rest, the three first are of a greenish yellow color, each with a scent peculiar to it, and when a piece of litmus paper is immersed in either, the color is destroyed. Nitrous oxyde is without odour, and has no effect upon the color of litmus. Ammoniacal gas is of strong scent, and shows alkaline properties. Sulphuretted hydrogen is inflammable, and smells like garlic. Cyanogen has the odour of prussic acid. Carbonic acid is without odour, or has very little, and is rendered turbid upon the addition of a little lime water.

1886. *Gases not absorbed by water.*—Immerse in a jar containing a gas of this description a lighted taper; if the flame is rendered more vivid the gas is oxygen. If it be immediately extinguished without inflaming the gas, it is nitrogen. If the gas be inflamed, it must be either hydrogen, or one of its compounds, or carbonic oxyde. Phosphuretted hydrogen inflames spontaneously, or without the application of a lighted taper; it smells of phosphorus. Arsenuretted hydrogen has a very strong fetid smell. These being taken away, only six gases remain; two of which burn with a strong white light. These are light carburetted hydrogen, and olefiant or coal gas; the last is known from the former by its forming an oily liquid when united with chlorine. Hydrogen and carbonic oxyde, two others of these gases, are difficult to examine. The gas to be tested is to be mixed with half its volume of oxygen, and inflamed by the electric spark in a very strong tube, closed at the top, and standing in water. If hydrogen, the whole mixed gas will explode, and become changed into water; consequently after the explosion the tube will have no gas of any kind in it, but if it be carbonic oxyde, and the same quantity of oxygen be mixed with it and exploded, the effect will be that a quantity of carbonic acid gas, equal in amount to the carbonic oxyde employed, will be left in the tube—both these gases burn with a dull blue flame. Hydrozincic gas is, as before stated, not distinct from hydrogen, but holding minute particles of zinc in solution. When it is burnt, the blue flame is accompanied by white specks or minute sparks. Potassuretted hydrogen, the only remaining gas, is peculiar in its effect upon water, being when water is added to it not absorbed, but decomposed, changing into hydrogen and alkali, which alkali gives to the water its own properties.

TESTS AND REMEDIES FOR POISONS.

In cases of poisoning great difficulty often arises from many causes, particularly from the impediment occasioned by other contents of the stomach, by the alterations which that poison may have undergone, or the absorption which may have taken place. The circumstances of death will, however, mostly indicate the nature of the poison, whether acrid or narcotic. Among vegetables and among the objects of inorganic chemistry very numerous indeed are the matters which may act as poisons; and some of them of that nature that no trace remains after even a short period. For obvious reasons, these last will not be touched upon; and the former, containing every thing which can by possibility act as a poison, form too numerous a class to discuss in a non-medical work. The number of materials feloniously used, or likely to be taken by accident, are arsenic, corrosive sublimate, oxalic acid, antimony, salts of copper or lead, the mineral acids, prussic acid, and laudanum. The surest tests and antidotes for these are given beneath.

1887. *Arsenious acid. White arsenic.*—The tests given in page 211 for the discovery of this acid are to be considered inferences, rather than proofs of its existence in the human stomach, as the numerous organic matters most likely to be present render liquid tests like these very uncertain; the only sure one is the reduction of the acid to the state of metal. For this purpose Dr. Christison recommends sulphuretted hydrogen to be employed, dispensing with the other tests. The liquid should be boiled and filtered in the first place, and then acidulated with acetic acid, to coagulate any albuminous or other organic matters that might interfere with the subsidence of the precipitate, or by the viscidity they induce, with the filtration; and also to prevent any alkaline matter present from interfering with the precipitation. Acetic acid is preferred to nitric or sulphuric acid, as it does not decompose sulphuretted hydrogen. A stream of sulphuretted hydrogen is then to be passed through the liquid, continuing it at least for half an hour. The liquid is then to be boiled for a few minutes to expel any excess. The precipitate is then to be collected on a filter, washed repeatedly with water, and dried by a temperature not exceeding 213°. On mixing it intimately with about twice its weight of black flux, and exposing it to heat in a glass tube over a spirit lamp, the potassium in the black flux combines with the sulphur, and the metallic arsenic is sublimed. If a crust of metallic arsenic should be obtained, its steel grey lustre, its brittleness, the facility with which it is volatilized, and the garlic odour that is at the same time produced will be sufficient to distinguish it from any other substance.

1888. *Detection of arsenious acid by forming arsenuretted hydrogen.*—Mr. Marsh has proposed a very ingenious mode of detecting arsenic in compound solutions, by converting it into arsenuretted hydrogen.

This is effected by acidulating the solutions with aqueous sulphuric acid, and adding fragments of zinc, proceeding in the same manner as in the preparation of hydrogen gas. When this gas is developed in any solutions containing arsenic, it combines with the metallic arsenic, and forms arsenuretted hydrogen gas, which is thus separated at once with effervescence from all the materials that might have influenced the re-action of tests applied to the solution.

1889. On the small scale a bent glass tube A B may be used, a piece of zinc A being suspended from the cork into which the stopcock is fixed, the stopcock being opened slowly, when a sufficient quantity of gas has been accumulated, and a light applied, so as to inflame the arsenuretted hydrogen as it escapes. The gas ought to be produced slowly when the quantity of materials is small, by using no more aqueous sulphuric acid than is necessary to produce effervescence.

1890. When a larger quantity of materials is to be examined, an apparatus may be constructed of the form shown in the annexed figure, and resembling Dobereiner's lamp.

1891. In examining arsenuretted hydrogen it may be recognised by the flame with which it burns, but more particularly by the deposition of metallic arsenic and arsenious acid when the flame is directed upon a piece of cold glass or porcelain. The hydrogen produces water as it combines with the oxygen of the air, and the metallic arsenic with oxygen forms arsenious acid. But as the exterior film of gas is consumed, part in the interior is decomposed and precipitates metallic arsenic, precisely in the same manner as coal-gas deposits carbon. A great variety of appearances may be seen, and concentric rings of arsenic or arsenious acid according to the size of the plate applied, and the manner in which it is brought in contact with the flame.

1892. Many other methods of detecting the presence of arsenious acid have been proposed, but none of them are so important as those already described, with the exception of one, lately pointed out by Mr. E. Davy, which promises to be of great value. This consists in placing any liquid suspected to contain it on a piece of platinum, and touching it then with a piece of zinc; metallic arsenic is immediately deposited upon the platinum, should the liquid contain any, and Mr. Davy states that he was enabled to detect the presence of arsenic shewing its characteristic properties, with the 500th part of a grain precipitated in this manner.

Arsenic produces gangrene of the stomach and intestines. Its only remedies are energetic and instantaneous vomiting and purging. For this purpose small doses of sulphate of copper, such as a table spoonful of the solution, and often repeated, may be taken; or a scruple or two of the sulphate of zinc, but the stomach pump is preferable.

1893. *Tests for antimony as a poison.*—This if taken into the stomach is mostly in the state of emetic tartar, (tartrate of antimony and potass) and to detect it, first add a mixture of tartaric and hydrochloric acids; let any coagulated organic matter subside, pour off the clear liquor, and transmit through it sulphuretted hydrogen, which will throw down the characteristic yellow orange powder of sulphuret of antimony. Dissolve this by the aid of heat in strong hydrochloric acid, boil it until sulphuretted hydrogen and fumes of hydrochloric acid cease to arise from it, and then dilute the solution with water, if antimony be present, a white cloud will immediately pervade the liquid, the use of the tartaric acid in the former part of the experiment is to hold any oxyde of antimony from the action of the hydrochloric acid, or either the chloride of antimony would be made at first, or the oxyde of antimony be lost among the organic matter deposited. The remedies are those of arsenic.

1894. *Tests for mercury as a poison.*—The most poisonous salt of mercury that is likely to be met with is corrosive sublimate. This if taken, may be rendered comparatively inert by the patient swallowing the whites of several eggs, albumen having the property of changing the virulent bichloride of mercury, (corrosive sublimate,) into the more harmless chloride or calomel. To detect the metal, let the solution supposed to contain it be boiled with aqua regia; filter the solution, boil the liquid to expel any excess of acid, and add the usual tests for mercury, before given.

1895. *Tests for copper as a poison.*—Mix with the liquid supposed to contain copper, acetic acid in excess. If the salt of copper has been decomposed by the contents of the stomach as is very likely to be the case, this acid will dissolve any uncombined oxyde of the metal when assisted by heat. The copper therefore being held in solution by the acid, forming with it acetate of copper a soluble salt, the organic solid matter left by filtering may be thrown away, and the liquid which filters be tested in the usual manner for copper; ammonia is a good test in this case. The fine blue color it gives cannot be mistaken.

1896. *Tests for lead as a poison.*—Sugar or lead or the subacetate of lead is most likely to be the salt present; this is decomposed immediately by Epsom salts or Glauber's salts, becoming converted into the insoluble sulphate of lead and the soluble acetate of either magnesia or soda. Lead may however be present as a carbonate or other salt, soluble or insoluble; in either case in order to detect its presence, the liquid supposed to contain it may have nitric acid first added to it, to take up the lead. Then it is advisable to pass sulphuretted hydrogen through the solution, this will throw down a sulphuret of the metal, this being collected, dried, and boiled with nitric acid, will be decomposed and the lead taken up. To the solution of lead thus formed, the usual tests may be applied, or the sulphur may be driven off from the sulphuret by heat.

1897. *Tests for the strong acids as poisons.*—These when taken into the stomach are often very difficult to discover, as it is necessary to know if they have been admitted in a free condition or in combination. Also as to the hydrochloric acid, as it exists naturally in the stomach extreme caution is requisite, a fair inference may however be mostly made, by the appearance of the fauces and œsophagus, being violently inflamed, and their mucous lining removed by the corrosive nature of the acids employed. The antidotes for these when taken internally are the alkalis potass, or soda, best administered in their state of carbonate, which by neutralizing the acid render it inert. When removed from the stomach, its contents may be combined with potass, filtered and evaporated to obtain crystals of nitre; these crystals may be redissolved and tested by the protosulphate of iron, or strong sulphuric acid, when a brown insoluble powder will fall down, if nitric acid form one part of the crystallized salt.

1898. *Tests for sulphuric acid as poison.*—This acid when united to organic matter is difficult to discover, because of the decompositions which take place. The presence of any uncombined acid of any kind may be tested by litmus paper, and the acid liquor may be tested for sulphuric acid, yet even the chloride of baryta is not always a test for sulphuric acid under these circumstances. First distil the liquid obtained to dryness, (the receiver containing dilute ammonia,) then add aqua regia to the contents of the receiver, and add the chloride of barium, the sulphuric acid being by the above means separated from organic matter will obey the usual test. Sulphuric acid being often used in medicine; also to adulterate vinegar, to flavor acidulated drops, and for other harmless purposes, may be found in the stomach in small quantities frequently; the quantity found should therefore be considered. This acid usually changes the organic bodies in connexion with it to a dark color, whereas nitric, hydrochloric, and especially oxalic acid, have a tendency to bleach them.

1899. *Tests for hydrochloric acid as a poison.*—As this is a constant ingredient of the gastric juice, it is only when in considerable excess that any inference can be drawn from its presence. The liquid should be distilled to dryness, or even to redness, the acid if present will be distilled over, and the chlorides be decomposed. The distilled liquor will, if the acid be in quantity, smell of hydrochloric acid. It may be tested with nitrate of silver; sometimes during the distillation white fumes of hydrochlorate of ammonia will pass over into the receiver, but these will not vitiate the test.

1900. *Test for oxalic acid as a poison.*—As oxalic acid is kept for many processes of the arts, as well as in families for cleaning leather, taking out ink spots, &c., and is moreover extremely like Epsom salts in appearance, accidents frequently occur by the inadvertent exhibition of this poison instead of Epsom salts. The extremely acid taste will instantly inform the person who takes it of the mistake, confirmed as it is by the hot burning sensation which immediately succeeds. As soon as it is known that oxalic acid has been taken, lime water, lime in powder, or chalk should be taken directly; the scrapings off the ceiling or a plastered wall will answer the purpose. This converts the oxalic acid into the oxalate of lime, which is insoluble and harmless. To detect it after death; mix the liquid supposed to contain it with potass. Then filter, and mix with subacetate of lead; the oxalate of lead falls down. Wash this precipitate well with water, and decompose it by sulphuretted hydrogen. This by forming a sulphuret of lead sets free the oxalic acid separated from organic matter. The usual tests may now be applied.

1901. *Test for prussic acid as a poison.*—The presence of this acid may sometimes be detected by its smell of almond kernels. To prove its presence, mix the contents of the stomach with sulphuric acid to saturate free ammonia, and then distil; the liquor which comes over may be submitted to the tests of the metallic salts. The best remedy for prussic acid taken internally is liquid ammonia administered instantaneously.

1902. *Test for the presence of laudanum.*—The active principle of laudanum is morphia; this unites with acids forming salts. If a liquid impregnated with laudanum then have acetic acid added to it, an acetate of morphia is obtained; to test this, we may use nitric acid which occasions a reddish color, or the persalts of iron which occasion a blue green color. Iodic acid is, however, according to Serullas, the best test of the presence of morphia, it produces a reddish brown color, and the odour of iodine is immediately perceptible; if however the morphia be minute in quantity its effect may not be apparent, until starch be added to the solution to show the presence of the free iodine. Emetics, and after these have acted, acids, are the best remedies for persons poisoned by laudanum; the patient being kept roused as much as possible.

SUNDRY TESTS.

1903. *Test for hard or soft water.*—Soap dissolved in alcohol is employed to ascertain the hardness of water. With distilled water it may be mixed without any change ensuing, but if added to a hard water it produces a milkiness, more considerable as the water is less pure. Thus all uncombined acids, and all salts except those of alkalis decompose soap, and occasion that property in water which is called hardness.

1904. *Dr. Paris's test for the purity of wine, &c.*—Put into a crucible 1 ounce of sulphur and 1 ounce of pure lime, and keep them in a white heat for nearly half an hour; when cold, add 1 ounce of the super-tartrate of potass, and boil the whole in a mattrass with some distilled water for about half an hour. Decant the supernatant liquor into small phials, adding about 20 or 30 drops of hydrochloric acid to each. The phials must be well stopped and preserved for use. Lead, copper, and other deleterious metals will be precipitated of a black color by this liquid, if poured in the quantity of only a few drops into the suspected wine or cyder. The hydrochloric acid is added to this test to prevent the precipitation of iron, which might exist in the wine without any mischief resulting from its use.

1905. *Test for alum in wine.*—Add to the wine a sufficient quantity of a strong solution of chlorine in water until it is changed to a yellow color; let the precipitate, (composed of the chlorine and the vegeto-animal matter contained in the wine,) which immediately forms, become settled; then filter the liquor, and evaporate it to one-fourth of its volume. It will now in consequence of the presence of the alum have an astringent sweetish taste, and will furnish a white precipitate on the addition of nitrate of barytes, which is insoluble in water and in nitric acid. It will give a yellowish-white precipitate with pure potass that is soluble on the addition of an excess of the potass; and a precipitate, of the same color, with the sub-carbonate of soda, which is decomposed by the action of heat into carbonic acid gas and alum; substances easily to be recognized by their characteristics.

1906. *Tests for the purity of acetous and acetic acids.*—These acids, from distillation in lead and copper vessels, very often contain acetates of lead and copper in solution; and they are often wilfully adulterated by sulphuric acid to increase their acidity. To detect these, pour into three wine-glasses some distilled vinegar, (acetous acid,) or one dram of the acetic acid, diluted with three drams of distilled water. Into one of these pour some Harrowgate water, (which contains sulphuretted hydrogen.) If lead be present in the acid a very sensible black precipitate will fall down. Into the second glass pour a solution of pure ammonia. If copper be present the whole will immediately become light blue. Into the third pour a few drops of the solution of chloride of barium; if the acid contain sulphuric acid, the liquid in the glass will instantly become quite milky.

1907. *Test for the purity of ether.*—If any ether will redden litmus paper immersed in it, it is a proof that it contains superabundant acid, such as the sulphuric, acetic or nitric, consequently the ether cannot be pure. A superabundant portion of sulphuric acid in sulphuric ether may be discovered by pouring a few drops of the solution of chloride of barium into a dram of the ether.

1908. *Test for steel.*—Let fall a single drop of nitric acid on any cutting or other instrument supposed to be steel. If steel, the part whereon the drop fell will immediately turn black. No effect will for a considerable time take place if nitric acid is dropped on pure iron. The blackening of the steel is owing to the combination of its iron with the acid, and the consequent precipitation of the carbon.

1909. *Test for chalk in white lead.*—White oxyde of lead is often adulterated by the carbonate of lime; to detect this, pour over a dram of the suspected oxyde four drams of pure acetous acid. This will dissolve both oxyde and chalk, but if a few drops of a solution of oxalic acid be now poured in, a very abundant white precipitate of oxalate of lime will take place.

1910. *Test for the purity of calomel.*—The specific gravity of calomel is a very good test to distinguish it from most other white powders, as it is much heavier than any of them; but the most unequivocal test is by rubbing some of the powder in a mortar with some pure ammonia, or by shaking it in a phial with lime water. In either of these cases, if calomel is present and in a pure state, the combination will become intensely black. Chalk, plaster of Paris, &c., will become deposited.

1911. *Test for the purity of essential oils.*—Essential oils are often adulterated by alcohol, also by fixed and essential oils of cheaper price. To detect alcohol, pour 2 drams of distilled water into a dram of the suspected oil; the whole will become milky if alcohol be present. To detect fixed oils, as almond and olive oil, let a drop of the suspected oil fall on a piece of writing paper, and hold it near the fire. If the whole evaporates and leaves no stain upon the paper, there is no fixed oil present; but if a stain remains, that is if the part where the drop fell appears greasy or transparent, the essential oil has been adulterated either by almond or by olive oil.

1912. *Test for the purity of mercury.*—Dissolve a small quantity of the suspected mercury in as much nitric acid as will saturate it, divide this solution in three wine glasses, and into the first pour some distilled water; if a white precipitate is thrown down it is an indication of the presence of bismuth. Into the second, pour water saturated with sulphuretted hydrogen gas, and a brown precipitate will discover the presence of even the smallest quantity of lead. Tin is known to exist in union with mercury, by dropping in the third glass chloride of gold, a little diluted, when a purple precipitate will take place.

1913. *Test for the purity of magnesia.*—On account of adding to its weight, magnesia is very often adulterated by chalk. To discover this imposition, put some carbonate of magnesia into a tumbler, and pour over it some diluted sulphuric acid, as long as a discharge of carbonic acid gas by effervescence takes place. If the whole is now quite limpid, and no white powder remains, the magnesia has been free from adulteration, but if a precipitate falls, it has been adulterated by powdered chalk.

1914. *Test for the purity of Ethiops mineral.*—For fraudulent purposes this article is very often adulterated by ivory black: and to detect the imposition, nothing more is necessary than to put about a dram of it on a shovel and to hold it over the fire; if the sulphuret be pure, the whole will be volatilised; if not, ivory black is present. To ascertain whether the mercury and sulphur are properly combined, rub a small quantity on a piece of gold: and if the gold be whitened like silver on the part rubbed, the mercury is not properly combined, but exists in the state of very minute globules. If on the contrary it leaves no mark, it is well combined with the sulphur. The white stain is caused by the affinity existing between gold and mercury.

1915. *Test for the purity of vermillion.*—Red sulphuret of mercury, or vermillion, is often adulterated by red oxyde of lead, chalk, and a substance known by the name of dragon's blood. To detect these, put a small portion of the vermillion into three wine glasses: into one of these pour a little alcohol, if dragon's blood exist in it, the alcohol will be slightly tinged of a red color; in a few days, if shaken in a phial, it will be quite red, or if held over a lamp in a Florence flask, the alcohol will soon acquire a deep color. Into another of the glasses pour some pure acetous acid, if the chalk be present, effervescence will be the consequence; but as a further test, pour the clear liquid into another glass, and add a solution of oxalic acid; in this case, a white precipitate of oxalate of lime will fall down. To detect red lead, pour some acetous acid into the third glass, and decant the liquor; into this pour some Harrowgate water; if lead exists in it, a black precipitate will fall down.

1916. *Test for hydrogen in sulphur.*—Sir H. Davy proved the existence of hydrogen in sulphur as follows:—a bent glass tube having a platinum wire hermetically sealed into its upper extremity was filled with sulphur. This was melted by heat, and a proper connexion being made with the voltaic apparatus of 500 double plates, each six inches square, and highly charged, a most intense action took place. A very brilliant light was emitted; the sulphur soon entered into ebullition; elastic matter was evolved in great quantities; and the sulphur from being of a pure yellow, became of a dark reddish brown tint. The gas was found to be sulphuretted hydrogen, or hydrogen gas holding sulphur in solution; and its quantity, in about two hours, was more than five times the volume of the sulphur employed.

1917. *Test for gum in solution.*—Pour into a solution of gum arabic, a little of the solution of acetate of lead; a very flocculent precipitate will fall down, composed of gum and oxyde of lead. Here the acetic acid quits the lead to combine with the water, consequently the oxyde falls down with the gum.

1918. *Test for the purity of olive oil.*—This phenomenon takes place, when a small quantity of the solution of acid per-nitrate of mercury is added to a quantity of pure olive oil, and shaken with it. The per-nitrate is prepared by dissolving without heat, 6 parts by weight of mercury in 7½ parts of nitric acid. The saline solution remains fluid, the excess of acid preventing its crystallization. When 8 parts of this solution are mixed with 92 of pure olive oil, and shaken from time to time, after some hours the whole congeals into a yellowish mass, and the next day it becomes solid like butter. This singular property of the per-nitrate renders it an excellent test of the adulteration of olive oil, by rape, poppy, and other seed oils; as the impure mixture will not become concrete, but will congeal according to the quantity of olive oil in it. Another circumstance adds to the excellence of this test; namely, an orange hue which it imparts to the seed oils, also a resinous precipitate which is thrown down from them by it. On the contrary, the Provence olive oil is rendered only very slightly yellow like fresh butter, while the Calabrian is perfectly white like tallow.

1919. *Test for the purity of alcohol.*—It is a common practice for apothecaries, in order to ascertain if spirit of wine be sufficiently strong, to pour some into a cup upon gunpowder, and then to set fire to it. If the spirit be sufficiently strong, after burning down to the gunpowder, it will inflame; but if too much water had been mixed with it, that would not take place, as, after the spirit was consumed, there would still be water enough to keep the gunpowder wet.

1920. *Test for organic matter.* The presence of organic matter often materially shields the action of re-agents, hence it is necessary often to ascertain if such be present. This may be done by heating a part of the matter to be tested in a *green* glass tube; in general the substance will become black, and thus show its organic nature. There are, however, a few which do not thus alter their color, as well as some inorganic matters which do; therefore it is necessary to throw the black heated matter into red hot nitre; if they deflagrate, they are sure to be of an organic character; or in other words they are thus proved to be charcoal.

APPLICATION OF THE SUBJECT.

In all the foregoing illustrations it has been supposed that the substances have been disunited, the object of the experiments has been therefore to detect a metal, or other body, when one only of its own class is present; but in minerals, alloys, mineral waters, natural salts, and where two, or in some instances several are combined, the process is much more difficult, yet in a commercial point of view this is by far the most important, not merely that we may learn the ingredients forming an acknowledged compound, but to ascertain whether matters are adulterated, and if so by what substance and to what extent. There is indeed scarcely an article of general consumption which is not or may not be thus contaminated, and which the chemist at one time or another is not called upon to examine and report. It is therefore necessary to consider the method of testing compound bodies as well as single ones, and of separating them into their simpler elements. To do this the following may assist.

1921. *To determine whether a mineral contains lead.*—Break a small portion from the ore, and observe the fragments and their brilliancy; now place a bit not larger than a pepper-corn on a piece of charcoal, then with the blow-pipe blow through the flame of a candle, directing the jet upon the mineral. If it contain lead, it will instantly discharge sulphureous vapors, and in half a minute, the lead will be reduced. The ores of this metal are numerous; the most common is blue lead ore, which occurs in great quantity, and from it the lead in commerce is produced. Others are of various colors, as grey, green, brown, yellow, and red.

1922. *To detect mercury in minerals.*—Earths or minerals of any kind, containing mercury, are most accurately assayed by distilling them with iron filings; but whether a mineral contains mercury or not may be easily discovered, by strewing it, when powdered, on a plate of hot iron, or on a hot brick covered with iron filings, and inverting over it a glass of any kind. The mercury, if the mineral contains any, will ascend, and attach itself in small globules to the sides of the glass. Mercury is found both in the native state, and as an ore combined with sulphur, &c. Native mercury is called living or running mercury, because it is seen to run in small streams at the bottoms of some mines. It is more frequently, however, imbedded in calcareous earths, or clays of different colors, from which it may be separated either by trituration and lotion, (the smaller globules coalescing by mutual contact into larger;) or by distillation. Cinnabar is the most common ore of mercury; it is found in an earthy form, resembling red ochre, sometimes in an indurated state, and, though generally red, it has been observed of a yellowish or blackish cast; it is mostly opaque, but some pieces are as transparent as a ruby.

This ore consists of mercury and sulphur combined together in different proportions; some cinnabars yielding as much as seven, others not three parts in eight, of their weight of mercury. Sulphur and mercury, being both volatile in a small degree of heat, would rise together in distillation, unless some substance, such as quick lime or iron filings, was added to the cinnabar, which by superior affinity can unite itself with, and detain the sulphur: whilst the mercury, not being able to support the heat, is elevated in vapor, and condensed in various ways in different works.

1923. *To detect gold in minerals.*—Scrape the mass with the point of a knife; if it be gold, it will be soft and may be cut like lead; or strike it gently with the small end of a hammer, if it be gold, it will be indented. Melt a small particle with the blow-pipe, if it be gold, its color will remain the same; but if it be brittle and hard to the knife and hammer, it is not gold. Place a few fragments upon a hot shovel, or under the flame of a blow-pipe: if the sulphur burn away, leaving scoria that is attracted by the magnet, this proves that it is a combination of sulphur and iron, commonly called iron pyrites. Put a few of the particles into a watch glass, and drop a little muriatic acid* upon it, and hold it over the flame of a lamp or candle until it boils; if it be gold no alteration will take place, but if not effervescence and change of color will be the result, which shows that the substance is acted upon by the acid. If no change take place with hydrochloric acid add aqua regia. A solution is now sure to ensue, to which the usual tests for gold may be applied.

1924. *To detect silver in minerals.*—A rich ore will be soft to the knife or hammer, and melt under the blow-pipe with little difficulty; and by repeated fusion with borax a bead of silver may be produced. A few small particles of the ore may be put into a watch glass, into which drop a little nitrous acid; then hold it over the flame until it is dissolved. After this dilute it with water, and stir it about with a bright copper wire; if any silver is present it will precipitate upon the copper, covering it with silver. Or add a little table salt to the solution; a white cloud of chloride of silver will fall down.

1925. *To detect copper in minerals.*—Place a small piece of supposed copper ore upon a piece of charcoal, with a little powdered borate of soda, (borax,) and direct the flame of a blow-pipe upon it. If it be rich ore it will be reduced to a bead of pure copper, coloring the slag green or reddish brown; it is sometimes necessary to repeat the fusion. Another method of detecting copper is as follows:—Reduce a small particle to powder; put it into a watch glass with a few drops of nitrous acid; if no action takes place, apply a little heat, by holding it over the flame of a lamp. The copper will soon be acted upon, and dissolved by the acid. Now add a few drops of water, and stir it with the point of a knife, or any piece of clean iron. The copper will leave its solution, and precipitate upon the iron, covering it, and giving it the appearance of copper.

1926. *To detect tin in minerals.*—The ores of this metal may, after having been pulverized, and mixed with borax, be reduced to the metallic state; but care must be taken not to continue the heat too long, as it will burn away; a little soot or soap melted with it will assist the operation. If this test is insufficient, the ore may be dissolved in a little nitro-muriatic acid, and precipitated of a white color, by pouring into the solution a little pure potass.

1927. *To detect manganese in minerals.*—Exposed to the flame of the blow-pipe, with borax, a purple glass is produced. Manganese may also be known by putting a little hydrochloric acid to a small quantity of the powder, and by holding a piece of wet printed cotton, &c. over the fumes. The color will be destroyed; also by immersing a piece of colored cotton, which will be bleached by the solution. Manganese has many varieties, and is distributed in great abundance. It may be known by its earthy appearance, and is commonly called black wad: this mineral contains fibres imbedded in it of a metallic lustre. Other varieties are composed of acicular fibres, sometimes aggregated, and have an iron-like splendour. It is very frequent in Devonshire, and when examined may easily be distinguished from iron, or any other substance.

1928. *Tests for iron ores.*—Iron may be detected by placing a small particle of iron ore under the flame of the blow-pipe; it will not melt, but after it has been kept red-hot a few seconds the magnet attracts it. Or reduce the particles to powder, put them into a watch glass, and add a drop or two of sulphuric acid; hold the glass over the flame of a lamp. When perfectly dissolved, throw the whole into a glass of water, to which add a few drops of tincture of galls. The product will be ink.

1929. *To detect platinum in minerals.*—Pound the ore and keep it red hot for some time, then dissolve in hydrochloric acid to remove earthy particles, and the residue in nitric acid assisted by heat. Nothing will be left undissolved but gold, platinum, and silica, with perhaps a trace of a rarer metal. Then collecting the undissolved portion, add to it aqua regia, this will dissolve the gold and platinum, and leave the silica. To the solution then add tests for gold and for platinum. If the platinum is to be separated, add to the solution in aqua regia the hydrochlorate of ammonia or potass to throw down the oxyde. The silica may be retained in the first process of roasting by adding potass to the metal in fusion, and washing by water previous to the use of the hydrochloric acid.

1930. *To detect cobalt in minerals.*—Melt by means of a blow-pipe a particle of the ore along with twice or thrice its weight of borax, a bright blue glass will be obtained very different from that with manganese.

1931. *To detect arsenic in minerals.*—Melt a small portion of the mineral, and if arsenic be present, a garlic-like odour will be separated.

1932. *To detect antimony, bismuth, and zinc in minerals.*—Melt it by the blow-pipe flame, on a piece of charcoal, continue the heat until white fumes arise, collect these, dissolve them in nitric acid, and add the usual tests to the salt thus obtained. Or a button of metal being formed by the heat it may be let fall from the charcoal, and afterwards tested for either or all the metals.

1933. *To analyze an amalgam.*—Heat it gradually in a small retort, having the extremity of its neck loosely stopped with linen rag, and immersed in water; the mercury will sublime and condense in the receiver, while the other metal or metals remain in the retort.

1934. *To analyze pewter, or an alloy of tin and lead.*—Introduce a certain quantity (100 grains for instance) of the alloy into a mattrass, add 6 or 7 times its weight of pure nitric acid, of the specific gravity of about 1.26, and expose it to a heat gradually raised. When the metallic particles have disappeared, and the acid ceases to give off nitrous gas, it must be evaporated to dryness, water poured on the residuum, and the whole thrown on a filter and washed, till the washings (which must be added to the filtered solution) no longer redden litmus, nor are blackened by sulphuretted hydrogen. The peroxyde of tin remaining on the filter must then be dried and calcined, and deducting 21.4 per cent. for the oxygen, its weight gives the quantity of tin in the alloy. Reduce the filtered liquid by evaporation, and precipitate by sulphate of soda; collect the sulphate of lead, wash, dry, and weigh it; 100 of sulphate of lead contain 68.1 of lead.

1935. *To analyze soft solder.*—Plumber's solder, which contains 2 parts of lead, and 1 of tin, may be analyzed like the preceding alloy; but if any copper be present, as is often the case, an additional operation is necessary. After the lead has been separated, subcarbonate of potassa or soda must be added to the solution to throw down the copper in the state of subcarbonate, which a red heat will convert into oxyde, from whose weight that of the metal is deduced.

1936. *To analyze an alloy of tin and copper.*—The analysis of this alloy must be conducted like that of tin and lead, except that, instead of sulphate of soda, we must add to the filtered liquor an excess of solution of hydrate of potassa; wash the precipitate of deutoxyde of copper thus obtained till the washings are not affected by nitrate of baryta, and dry and heat it red to convert it into pure deutoxyde of copper. Its weight, deducting 20 per cent. for oxygen, gives that of the copper.

1937. *To analyze gun metal.*—This is generally composed of 89 parts copper and 11 tin, which must be separated by nitric acid; but as a little iron and even lead may always be suspected in the alloy, and would be dissolved with the copper, the solution must first be concentrated to drive off the greater part of the acid in excess, then diluted with water, and the lead thrown down by sulphate of soda. To the filtered liquor add an excess of ammonia, which will precipitate the oxyde of iron in red flakes, and retain the copper in solution. The iron being separated, caustic potassa must be added in excess, and the whole evaporated to dryness to expel the ammonia; the residuum heated in distilled water and the oxyde of copper collected, &c.; the weights of the several metals will then be deduced from the sulphates and oxydes obtained. The alloy of gongs and cymbals is similar to the preceding, differing only in the proportions of the metals. They may be analyzed in the same manner.

1938. *To analyze bell metal.*—Tin and copper serve also as the bases of this alloy, but zinc, lead, and iron are likewise often found in it, which renders its analysis more complicated. The alloy may be treated in the same manner as the gun metal, but after the addition of caustic potassa, and evaporation to dryness, the residuum must be boiled in distilled water in order that the excess of alkali may redissolve the oxyde of zinc, which may then be separated as directed.

1939. *To analyze an alloy of lead and antimony.*—This analysis may be made precisely as that of the alloy of tin and lead, *Ex.* 1945, deducting 26.5 per cent. for the oxygen of the deutoxyde of antimony.

1940. *To analyse tin and antimony.*—Solution of the alloy in aqua regia, and precipitation of the oxyde of antimony by water is impracticable in the analysis of this alloy, in consequence of the antimony carrying a large quantity of the oxyde of tin down with it. The following method is recommended by M. Chaudet:—The proportion of antimony in the alloy must be pretty nearly ascertained by a previous experiment on 5 parts of the alloy and 100 of tin fused together, laminated and treated with hydrochloric acid; the undissolved portion will indicate pretty nearly the quantity of antimony. The alloy is then to be fused with such a portion of tin, that this metal may be to the former as 20 to 1, including the tin in the alloy. The addition of the tin must be made with some care that the combination of the metals may be perfect. M. Chaudet places them wrapped in paper in a small crucible, covers them with charcoal powder, and fuses them under the muffle of a cupelling furnace. The button when cold is cleaned and laminated, cut into small pieces, and fused again as before; and this operation is repeated a third time, but without laminating the button, with a piece of paper placed between the metal and the charcoal powder, that the button may be perfectly homogeneous. The new alloy is then to be rolled into a very thin plate, cut into small pieces, and boiled in a flask with an excess of pure hydrochloric acid, of the specific gravity of 1.19, for two hours and a half at least. The whole of the tin will be dissolved, but the antimony remain untouched. The solution is then to be diluted with distilled water, and the insoluble matter collected on a filter; its weight will be exactly that of the antimony in the alloy. If the alloy contain any lead it must be laminated with great care, as that metal adds extremely to its brittleness. The quantity of lead may be ascertained by treating a portion of the alloy with nitric acid, and precipitating the lead by sulphuric acid. M. Chaudet has also analysed an alloy of tin and bismuth in the same manner, but in this case it is better to use nitric acid, which dissolves the bismuth and leaves the tin.

1941. *To analyze printers' types.*—These are formed of 4 parts of lead, 1 of antimony, and a very small portion of copper. Separate the antimony by nitric acid, as directed, and treat the solution in the same manner as that recommended in the analysis of plumber's solder.

1942. *To analyze an alloy of zinc and copper.*—Dissolve 100 grains of the alloy in weak nitric acid with a gentle heat, dilute the solution with a little water, and add a considerable excess of hydrate of potassa or soda; boil for a quarter of an hour, filter and wash the residuum (adding all the washings to the filtered solution,) till the water does not turn syrup of violets green, or paper stained with turmeric, brown. From the weight of the deutoxyde of copper remaining on the filter, when dried and calcined, deduct $\frac{1}{5}$ for oxygen; the remainder gives the proportion of copper in the alloy. To the filtered alkaline solution, containing the oxyde of zinc, add first a small excess of hydrochloric or sulphuric acid, and then subcarbonate of potassa or soda; carbonate of zinc will fall down, and being washed, dried, and heated red, will be converted into oxyde; the weight of which, deducting 19.61 per cent., gives that of the zinc.

1943. *To analyze yellow brass.*—When brass consists merely of zinc and copper, the preceding analysis is all that is necessary to determine their proportions; but it sometimes contains besides a small portion of lead. In this case, after solution of the alloy in nitric acid, and the expulsion of the greater part of the excess of acid by heat, the lead must be separated by sulphate of soda, and the remaining solution treated in the manner just mentioned.

1944. *To analyze an alloy of silver and gold.*—Laminate the alloy, and treat it by nitric acid as in the preceding analysis, till nitrous gas ceases to be disengaged; the residuum well washed, and heated red, gives the quantity of gold. Next pour hydrochloric acid into the solution to throw down the silver, wash the precipitate, dry and weigh it; 100 parts of chloride of silver are equivalent to 75.5 of silver. If the proportion of silver in the alloy be very small, the nitric acid will only effect its partial solution; in that case add as much silver to the alloy by fusion as will make it at least equal to three-fourths of the mass. Account must be taken of the quantity of silver thus added at the end of the operation.

1945. *To analyze an alloy of silver and copper.*—Dissolve the alloy in nitric acid, and dilute the solution with water, throw down the silver by hydrochloric acid, and filter the liquor, washing the precipitate till ammonia ceases to produce a blue color; then mix the washings with the filtered liquor, reduce it by evaporation, and add an excess of hydrate of potassa or soda to separate the deutoxyde of copper, from which the quantity of copper in the alloy is ascertained, as that of the silver is learnt from the chloride.

1946. *To analyze an alloy of silver, copper, and gold.*—This alloy also must be treated with nitric acid, which will dissolve the silver and copper and leave the gold untouched, whose proportion is to be ascertained as in *Ex.* 1944, and that of the silver and copper as mentioned. (*Ex.*1945.) In this analysis, as in the two preceding, if the alloy contain too little silver or copper in proportion to the gold for the nitric acid to act readily on it, it must be combined with an additional quantity of one of them, and by preference with silver, because that metal not being readily oxydated, it is easy to keep account of the exact quantity added.

1947. *To analyze fusible metal. (Bismuth, tin, and lead.)*—First heat the alloy in excess of nitric acid of the specific gravity of about 1.26, till the nitrous acid gas ceases to be evolved. The liquid must then be evaporated nearly to dryness, and the remaining mass washed with successive portions of water; by these means all the nitrate of lead will be dissolved, and a white residuum obtained, consisting of the oxydes of tin and bismuth. This being treated afresh with nitric acid, the whole of the oxyde of bismuth will be re-dissolved; but in order to separate the portion of nitrate of bismuth, which may adhere to the oxyde of tin without decomposing it, the latter must be washed with weak nitric acid; this done, the analysis is almost finished. It is only necessary to dry, calcine, and weigh the oxyde of tin to obtain the quantity of that metal; for that of the bismuth evaporate the solution of its nitrate to dryness, decompose this by heat in a platinum crucible, and weigh the oxyde; 100 parts contain 89.87 of bismuth. Lastly, precipitate the lead by sulphate of soda, &c.

1948. *To analyze an alloy of nickel and cobalt.*—Dissolve the metals in nitric acid, then add liquid ammonia in excess, this will first attack the nitric acid, throwing down the metals, and afterwards dissolve the oxydes thus formed; dilute this solution and add pure potass or soda. This will immediately throw down the nickel, but not the cobalt.

1949. *To separate iron from manganese.*—Dissolve the metals in aqua regia, add a solution of hydrochlorate of ammonia, and then pour in pure potass. The iron will be precipitated immediately, but the manganese will remain in solution as a double salt.

1950. *To analyze several earths when mixed together, as silica, alumina, baryta, strontia, lime, and magnesia.*—Treat the mixture with hydrochloric acid, the silica will remain, the rest be dissolved. Filter the solution, and weigh the silica remaining on the filter. Then add solution of the sulphuret of ammonia—this separates the alumina; filter again, and weigh the alumina left. Then pour into the filtered liquor excess of hydrochloric acid, and heat it, to expel the sulphuretted hydrogen. Evaporate to dryness, and boil the mixed salts in strong alcohol: this will dissolve all of them, except the chloride of barium. Dilute the alcoholic solution with water, and pour into it a solution of subcarbonate of potass, to precipitate the lime, strontia, and magnesia. Convert the carbonates into nitrates by adding nitric acid, and heat these nitrates with alcohol; the nitrates of lime and magnesia will be dissolved, and the nitrate of strontia left. Then precipitate again with subcarbonate of potass, pour off the alcohol, and add weak sulphuric acid; the sulphate of lime will fall down, while the sulphate of magnesia will be held in solution.

1951. *Analysis of stones.*—Stones are natural combinations of various oxydes, sometimes containing as accessary principles, acids, combustibles, and salts. They are chiefly composed of silica, alumina, lime, magnesia, and the oxydes of iron and manganese. They sometimes, but rarely, contain glucina, yttria, zircona, potassa, soda, and oxyde of chromium; more rarely baryta and oxyde of nickel, and still more so lithia and the other oxydes. Silica and alumina are their most frequent and abundant elements. Most stones are too hard to be readily acted on by acids; they must first, therefore, be ground in an agate or flint mortar, in portions of eight or ten grains at a time, till reduced to an impalpable powder; then weigh off 50 or 100 grains, and put them in a silver or platinum crucible, with three or four times their weight of hydrate of potassa or soda. Cover the crucible with its lid, and expose it by degrees to a red heat, and after the matter is fused, or at least has become pasty, which will require about three-quarters of an hour, withdraw it from the fire, and when cool, pour water on the mass, and heat it again; repeat this operation several times, decanting each portion into a capsule with the greatest care not to lose an atom, till the whole is detached from the crucible. Hydrochloric acid must then be added by degrees, and the mixture stirred to assist the action of the acid. When the solution is complete, evaporate it to dryness to volatilize the excess of acid, boil the residuum in eight or ten times its bulk of water, and filter; the silica will be collected on the filter. The other bases will be obtained from the filtered liquor, (which must be mixed with the washings,) in the usual manner. A preliminary trial should be made to ascertain the constituent principles of the stone, and a separate one to determine their proportions.

If the sum of the weights of the several ingredients obtained by the analysis does not equal within a few hundredth parts the weight of the stone employed, it probably contains an alkali. To ascertain this, fuse a certain quantity of the stone with boracic acid, or nitrate of baryta, diffuse the mass through water, and treat it with hydrochloric acid; then evaporate the solution to dryness to drive off the excess of acid, pour water on the residuum, filter the liquor to separate the silica and boracic acid, deposited during the evaporation, and add subcarbonate of ammonia, which will decompose the salts of lime, magnesia, alumina, &c.; filter again to separate the precipitate thrown down by the subcarbonate of ammonia, evaporate the solution to dryness, and calcine the residual mass in a strong heat in order to volatilize the hydrochlorate of ammonia formed in the process. The new residuum will consist of the potassa, soda, or lithia, combined with hydrochloric acid. It must be decomposed by diluted sulphuric acid; the saline mass dissolved in water, and the alkaline sulphates separated; or the dry hydrochlorate may be first digested in strong alcohol, which will dissolve the hydrochlorate of lithia, and then the remainder converted into sulphates, and separated by crystallization.

If, notwithstanding the loss of weight, no alkaline matter can be found in the stone, it may probably contain an acid. This must be determined by submitting it to various tests, and its quantity accurately ascertained.

1952. *Analysis of clays.* — Clays being formed at most of silica, alumina, carbonate of lime, oxyde of iron and water, may be analysed by processes similar to those already described. The silica is to be extracted as in hard stones, then ammonia will precipitate the alumina and oxyde of iron from the acid solution; after which, filtering the liquid and adding subcarbonate of potassa, we obtain a fresh precipitate of carbonate of lime. Solution of potassa will separate the oxyde of iron and alumina in the usual manner. The quantity of water may be found by calcining a portion of the clay strongly in a platinum crucible, deducting from its loss of weight after the operation that of the carbonic acid of the carbonate of lime, which will be decomposed in the process, and will be known from the quantity of lime obtained in the analysis; 100 parts of lime indicate 78 of carbonic acid.

1953. *Analysis of a mixture of sulphuric, nitric, and hydrochloric acids.*—Pour an excess of nitrate of baryta into the solution, which will throw down all the sulphuric acid in combination with its base. The weight of the sulphate of baryta when well washed, dried, and calcined, will give that of the sulphuric acid; 100 parts of sulphate of baryta indicate 34 parts of sulphuric acid. For the quantity of hydrochloric acid, add an excess of nitrate of silver to the solution, collect the chloride, wash, dry, and weigh it; 100 parts of chloride of silver indicate 24.5 of chlorine, and consequently 25.27 of hydrochloric acid. For the nitric acid, first digest an excess of oxyde of silver in the mixture, for about half an hour, shaking it occasionally: then decant the liquid, wash the residuum, and add the washings to the liquid. Next drop in a solution of baryta water, till it cease to occasion any further precipitate; filter, and wash the precipitate, adding the washings, as before, to the mixture; then saturate the filtered liquid with a further portion of baryta water, and evaporate the whole to dryness. The oxyde of silver, and the first portion of baryta, will separate the hydrochloric and sulphuric acids, and the second portion will combine with the nitric acid. The nitrate of baryta, after being well dried, at a heat below incipient redness, will give that of the nitric acid: 100 parts of baryta indicate 40 parts of nitric acid.

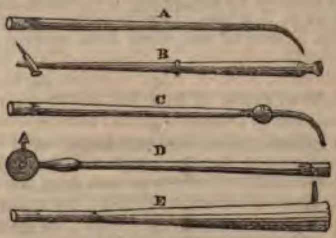
1954. *Separation of potass from soda.*—Add to the solution of these alkalis some hyperchloric acid; this will precipitate the potass, but not the soda.

1955. *Analysis of mineral waters.*—Waters are hard or soft according to the saline or acid matters contained in them; some few owe their peculiar character to the presence of sulphuretted hydrogen, like that of the medicinal spring at Harrowgate; these are instantly known by their fetid odour and their effect upon lead and other metallic oxydes. The ordinary hard and saline waters may contain one or more of the following substances, sometimes in the state of an oxyde, at others as a salt, those of Epsom for example contain the well-known Epsom salts, those of Cheltenham, the Cheltenham salts, and so on for numerous others. The substances most likely to be found are lime, oxyde of iron, carbonic acid, magnesia, soda, sulphuric acid, silica, and the hydrochloric acid. First boil a certain portion of the water in a glass retort, and let its aqueous part slowly distil over into a vessel of lime water; if this become turbid, it will show that carbonic acid is present, the amount of which is known by the quantity of the carbonates deposited altogether. The carbonates present, which may be those of iron, lime, or magnesia, will fall as precipitates, while the salts present are held in solution. Evaporate to complete dryness, and weigh the whole matter thus obtained, and which are necessarily the whole amount of impurity of the water, gas excepted. Add distilled water to the dry mass thus obtained, to dissolve the salts as before. Then separate the residuum, and add to it hydrochloric acid; this will dissolve the oxydes, but leave silica, if this be present; thus one matter is separated. Filter. Next add to the hydrochloric acid solution excess of ammonia; if part be dissolved, and the other left undissolved, separate the two. The solution may contain lime or magnesia; add oxalate of ammonia; if lime be present it will fall as an insoluble oxalate; if magnesia, it will remain in solution. The part undissolved by the ammonia may contain oxyde of iron and phosphate of alumina. This precipitate is to be re-dissolved in hydrochloric acid; potass is added, and the whole boiled. If dissolved, it will be alumina; if not dissolved, it will be the oxyde of iron, phosphoric acid, and perhaps a trace of magnesia. Finally add hydrochlorate of ammonia, and afterwards hydro-sulphuret of ammonia. What is now left undissolved is oxyde of iron, and the matter in solution will be phosphoric acid, and perhaps magnesia. If the gases given off at first do not render the lime water turbid they may be oxygen and nitrogen. For ordinary purposes the tests given previously for the various substances may be applied to mineral waters with success. Thus oxalic acid will always indicate lime if this be present, so sulphuric acid will detect lead and barytes, and gallic acid give indications of the salts of iron. So also if the oxalate of ammonia be used to the water; this remaining clear above the precipitate occasioned by boiling it, of course shows that no lime is then present: therefore, what was previously in solution is now deposited, and consequently it was a carbonate. The same is the case with the subphosphate of ammonia, the surest test for magnesia.

CHAP. VIII.

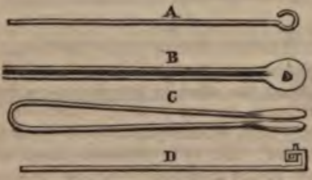
CHEMICAL EFFECTS OF HEAT, BLOW-PIPE ANALYSIS, GLASS AND PORCELAIN MANUFACTURE, ENAMELLING, VITRIFIABLE COLORS, &c.

For numerous purposes of chemical analysis, it is not merely convenient but absolutely necessary to subject the matter to a considerable degree of heat, before chemical composition or decomposition ensues. We have already alluded to this in considering the tests for oxalate of lime, in the red color given by strontian to inflammable materials, in melting metals, in procuring and reducing the oxydes, and in numerous other processes; we see it however still more forcibly in combining silica with other bodies, and in the decomposition of silicious minerals. There are two ways of applying heat, one by concentrating the rays of the sun upon the object by means of a large lens, the other by culinary or artificial fire applied in any manner which may be convenient. The first of these methods it is not necessary to describe here, as it belongs more to the subject or science of heat than to practical chemistry, as it is evident that a process which can only be adopted in sunshiny weather is not adapted for general purposes of experiment or analysis. The application of the heat emanating from burning materials is however a resource at all times. For manufacturing purposes a furnace of one construction or another is indispensible, but for analysis only a much simpler instrument, and one more readily put in action is infinitely to be prefered. This simple instrument is the *mouth blow-pipe;* a tube of metal or glass, having either of the following shapes will be found convenient for this purpose. A is a common blow-pipe; B shows that recommended by Dr. Wollaston, it is for convenience made in two or three joints; C is Bergman's blow-pipe, the bulb on the stem is for retaining the moisture of the breath; D is Pepy's blow-pipe, with a moveable jet; and E is the form used by Dr. Black.

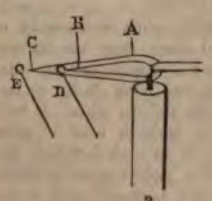


The object of the blow-pipe is to blow a current of air from the mouth on to the flame of a candle or lamp, and thus to increase the power of the heat which it produces; the effect is so strong, that nearly all of the most refractory substances are thus reduced to a liquid state, and when thus liquified by heat, they most frequently assume very marked characters, by which the substance under examination may be generally known from those which it may otherwise appear to resemble.

To support the objects.—There are many ways of holding the material, one is to place it on a piece of charcoal, a small hole being scooped out previously to receive it—for reducing oxydes to a metallic state this is an excellent method, as the charcoal by rapidly absorbing the oxygen from the oxyde converts that into metal; on the other hand when a metal, as zinc, lead, &c. is to be converted into an oxyde, such a support as charcoal impedes rather than assists the action. Glass tubes and capsules are also employed, the former may be closed at one end for some operations, or open at both ends for others; they may be 6 or 8 inches long, and of $\frac{1}{8}$ or $\frac{1}{4}$ of an inch internal diameter, made very thin, and of green or white window glass, as this is fused with much greater difficulty than flint glass, and moreover contains no lead. In the use of tubes of glass such as these, it is evident that the volatile products given off by the heat may be easily examined, which they cannot be by using a capsule of charcoal. A very valuable adjunct to the glass tubes in blow-pipe experiments is platinum, either in the state of wire or foil. A thin platinum wire 2 or 3 inches long, should have one of its ends bent into a ring; the size of the ring and the wire are shown at A, a piece of platinum foil shaped as a spoon, and of the form shown at B, may be used with much advantage. If a piece of platinum foil be placed on the leaves of a book, and a slight blow be given to its upper side by any with a convex point, it will sufficiently indent it to form a cavity, to hold the mineral to be tested. A pair of platinum tongs may easily be made by flattening the ends of a wire, and then bending the wire in the middle, so that the flat points shall meet each other as at C. A copper wire bent as at D is also of use in certain experiments. Some of the wires here spoken of should have two or three coils of the wire to form the ring at the end, as otherwise when certain materials are fused upon them the fused mass will owing to its fluidity fall out; this is particularly the case when microcosmic salt is used as a flux.



The nature of the flame is the next thing to be considered. A common candle or oil lamp with a flat solid wick is usually employed, and for ordinary purposes nothing is better, unless it be the flame of burning coal gas, which ever be examined, the constitution of each flame is the same. The tallow or the oil of the candle and lamp is decomposed by the heat, and resolved into inflammable vapor or gas; this meeting with the oxygen around the flame burns with a white light, but this light is only a film, for within the flame is a cavity full of unignited gas, which only becomes inflamed when it by passing upwards meets with oxygen. This will be more apparent by the preceding figures.



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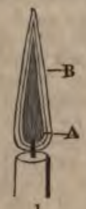

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In fig. 1 the letter B represents the film of luminous matter, and A the dark central part where the inflammable matter is not ignited. Now supposing we thrust the point of a blow-pipe into this hollow part, as in fig. 2, and supply air from the mouth, we shall of course contribute that element which is required to occasion the internal flame, and the consequence will be that the heat will be necessarily increased, and the flame elongated. Notwithstanding this double action there will still be a portion of the flame, as from B to C, where unconsumed gas is still present, and this portion of the flame which is of a *white* color possesses chemical powers, which the rest of it does not. The gases have in their then hot state a very powerful attraction for oxygen, and consequently when a substance containing oxygen is held in this part of the flame, as at D, the oxygen will in most cases leave the substance operated upon, and unite with the gas, the consequence will of course be that the substance will be deoxydated, or reduced metal; this part of the flame is therefore called the *reducing* flame, or from its position the internal flame, aad any thing to be reduced must therefore be held *within* the flame. The *outer* flame is drawn out by the blast of air into a long cone, the apex of which is of a *blue* color; this from its effects is called the oxydating flame, for if a particle of metal or other body be held *without* the flame, as at E, the heat it is subjected to will enable it to combine with the oxygen of the air around, and of course it will become oxydated, instead of as in the other instance being deprived of any oxygen it might be combined with.

A very convenient lamp for blow-pipe operations is that of Berzelius, represented beneath. It is a tin vessel or lamp supported upon a retort stand; a blow-pipe held to the flame, and air propelled through it, drives the heat to the charcoal.

Management of the blow-pipe.—This requires a little practice. First, let the student accustom himself to breathe through the nostrils with the mouth closed; when this can be done without inconvenience let him fill his mouth with air, so as to inflate the cheeks moderately, and continue to breathe without letting the air in the mouth escape; a few trials will accomplish this; the blow-pipe may then be introduced between the lips, and while the breathing is carried on through the medium of the nose, the cheeks will expel a stream of air through the blow-pipe, and by replenishing the mouth at each expiration, and merely discharging the *surplus* air through the nostrils, a facility will be acquired of keeping up a constant stream of air without fatigue.

The first impression of the heat should be gentle, as the sudden application of the high temperature is extremely liable to destroy those effects which it is most material to observe. Many substances decrepitate immediately they become hot, and when that is found to be the case, they should be heated red under circumstances which will prevent their escape; this may be effected with earthy minerals by wrapping them in a piece of platina foil, and with the metallic ores by confining them between two pieces of charcoal, driving the point of the flame through a small groove towards the place where the mineral is fixed, by which means a sort of reverberating furnace is made. The principal phenomena to be noticed are phosphorescence, intumescence, the exhalations of vapors having the odour either of sulphur or garlic, decrepitation, fusibility, and amongst the fusible minerals, whether the product is a transparent glass, an opaque enamel, or a bead of metal.

Fluxes.—Having first made some observations on a particle of the metal alone, with or without the use of glass tubes as afterwards mentioned, either the residue or a fresh piece should be examined, with the addition of a flux, more particularly in the case of the ores, as the nature of the metal may be generally decided by the color with which it tinges the substance used. Three fluxes are in common use.—1st. Carbonate of soda. 2nd. Borax, or borate of soda. 3rd. Microcosmic salt, which is a double salt of soda, ammonia, and phosphoric acid, and consequently a phosphate of soda and ammonia.

Minerals when offered to blow-pipe analysis are generally submitted to six operations.—1st. The substance is to be heated in a small glass tube, sealed at one end, the object of which is to ascertain if a sublimate occurs, or volatile matters arise; if so, whether they are acid, alkaline, or neutral, if it decrepitate or turn black, as well as its degree of fusibility.

2nd.—Heating it in a tube open at both ends to ascertain the effect of a current of air upon it; the current being stronger the more the tube is held perpendicularly.

3rd.—Heating it alone to observe the direct action of both flames, the oxydating and the deoxydating, its degree of fusibility, and particularly to observe the effect it has upon the color of the flame.

4th.—Heating it with carbonate of soda, to see if the mineral is reduced to a metallic form, whether it is soluble in the carbonate, becoming therefore a *glass*; or insoluble becoming a cinder or *slag*. The substance under this kind of examination may be supported upon charcoal.

5th.—Heating it with borax or microcosmic salt, to ascertain the color of the bead which it gives. For this purpose the rings of wire before described are useful. The method to be pursued is to wet the ring of the wire, then to dip it into the flux powdered, then to hold this to the flame until melted, then to imbed the mineral in it, and subject it to the heat required. A particle about the size of a grain of mustard is always sufficient, using with it two or three times as much of the flux.

1956. *To detect vegetable bodies by heat.*—Roll up a small piece of paper, and heat it in a glass tube, a white fume is produced, which settles on the sides of the glass as a brown colored oil, having a strong empyreumatic smell. Blue litmus paper held towards it turns red, and red turmeric paper turns yellow in the mouth of the tube, indicating the disengagement of a volatile acid. The paper heated in the tube turns black, but does not alter its form; it is in fact converted into charcoal.

1957. *To detect animal bodies by heat.*—In another glass tube heat a single grain of cochineal; a similar white fume appears to that produced by the previous experiment, a similar burnt oil, and a similar conversion of the mass into charcoal. But a more powerful and unpleasant odour is produced, and at the mouth of the tube red litmus paper turns blue, and yellow turmeric paper turns brown, changes that indicate the disengagement of ammoniacal vapor. These are the general characteristics of animal and vegetable bodies.

BLOW-PIPE TESTS FOR ALKALIS AND EARTHS.

Ex. 1958. *To detect potass and soda by the blow-pipe.*—Heated alone they are fusible. Heated with any soluble salt, potass communicates a faintish red color to the flame, and soda a greenish yellow, which is very characteristic. Also make a bead of glass with borax and oxyde of nickel, which will be *red;* if a particle of potass be melted with it it will change to a blue color, but not when soda is used.

1959. *To detect barium by the blow-pipe.*—Infusible except the hydrate and carbonate, all its combinations give a pale apple-green color, with soluble salts to the flame. With fluxes it melts into a colorless bead, opaque when cold. This and lime must not be supported by charcoal, or they are very likely to be absorbed when fused.

1960. *To detect strontia and lithia.*—Both give a crimson color to the flame, the strontia of the brightest tint; this last is infusible, but lithia fusible even when alone.

1961. *To detect lime by the blow-pipe.*—The intense light given off by lime when very strongly heated is peculiar to it and to zirconia, the last of which is not likely to be met with. Hence the formation of the *Drummond* light, which is a mixed jet of oxygen and hydrogen, (one inflammable, and the other the chief supporter of combustion) thrown upon a cylinder of lime, the intense light given out is visible at an immense distance. It is this ignited lime which constitutes the illuminating power of the oxyhydrogen microscope, and which gives to that instrument its superiority. The soluble salts of lime communicate to the blow-pipe flame a reddish brown color.

1962. *To detect magnesia and alumina by heat.*—They are both infusible when heated alone. Heated with microcosmic salt magnesia forms a glass which is opaque when cold, alumina one which is transparent. If these two earths are moistened with solution of the nitrate of cobalt, and then are heated strongly, magnesia becomes of a flesh color, and alumina of a fine blue.

BLOW-PIPE TESTS FOR METALLIC OXYDES.

Ex. 1963. *To detect oxyde of manganese.*—Heated alone no change takes place, except that the protoxyde turns brown from the loss of oxygen, and becomes the peroxyde. Melted with borax or microcosmic salt in the oxydating flame it gives an intense purple glass. In the reducing flame it is less colored, indeed colorless if quickly cooled. A very minute quantity must be used, or the color of the glass will be so intense as to appear black.

1964. *To detect oxyde of cobalt.*—This is only known from the last by the bright and clear blue color of the glass formed with fluxes. Cobalt is reduced on charcoal with carbonate of soda, but manganese is not.

1965. *To detect peroxyde of iron.*—This becomes in the reducing flame black and magnetic, and if the heat be strongly urged, and carbonate of soda and charcoal be added, it is reduced to metal. It gives in the same flame a greenish glass with fluxes.

1966. *To detect oxyde of zinc.*—When heated it communicates a very strong and whitish blue light; with borax it forms a transparent glass, or is reduced and volatilized, passing off in dense white fumes of oxyde. Moistened with the nitrate of cobalt, the flame is changed into a beautiful green, when the oxyde is heated without fluxes.

1967. *To detect oxyde of tin.*—It is reduced when heated alone, or quickly by the addition of charcoal and carbonate of soda. It forms a colorless glass with the other fluxes.

1968. *To detect oxyde of nickel.*—Mixed with potass it gives a red glass; with microcosmic salt also a red glass, but colorless when cold. With borax the same, but rather more orange in tint; that is in the oxydating flame, for in the reducing flame a grey, magnetic powder is produced, particularly if the fusion be aided by charcoal.

1969. *To detect oxyde of copper.*—This metal gives very different characters under different circumstances, when alone in the oxydating flame the oxyde fuses, and in the other is readily reduced; melted with borax it gives in one flame a green color while hot, in the other a reddish brown, and which is increased by the addition of tin. With carbonate of soda it affords a mass which is green when hot, colorless and opaque when cold. Its salts, except the chloride and bromide, give a green color to flame; the chloride and bromide give a blue.

1970. *To detect lead.*—This is soon reduced with or without charcoal, it first fuses to a fine orange colored glass. (litharge) It gives a *blue* flame, and forms a yellow glass with the fluxes, that with borax is nearly colorless when cold, and that with carbonate of soda, nearly colorless *until* cold.

1971. *To detect antimony.*—This metal is also soon reduced on charcoal, but instead of becoming glacial as lead does, it fuses and sublimes, giving a *green* color to the flame of the lamp. The glass it forms with fluxes is colorless in all cases when cold.

1972. *To detect bismuth.*—Heated alone it fuses and becomes dark brown, losing much of this color as it cools. With borax it forms a colorless bead even while hot; whereas that with antimony is with the same flux, yellow while hot; so also with microcosmic salt. Also the glass of both this and antimony are colorless when cold, that of antimony is yellow while hot, and this metal of a brownish red, that is in the oxydating flame; for in the other, both metals are reduced into a greyish mass, the bismuth however with by far the greater facility.

Tests for arsenic. See *Ex.* 1889.

1973. *Tests for oxyde of chromium.*—Mixed with microcosmic salt, it becomes red while hot and green; when cold in both flames.

1974. *Tests for oxydes of mercury.*—The oxydes are reduced, and speedily volatilized, giving no smell, but depositing the metal in globules upon any thing cold, particularly upon a leaf of gold if held over it.

1975. *Tests for oxyde of silver.*—Heated alone it is instantly reduced into a bead of silver; mixed with borax it gives a milk-white opaque glass in the oxydating flame.

OTHER BLOW-PIPE TESTS.

*Ex.*1976. *Tests for sulphur and sulphurets.*—Sulphur is at once known by its combustibility, the color of its flame, and peculiar suffocating odour of its fumes. Heated in a glass tube closed at bottom it sublimes in red drops, which afterwards become yellow, and crystallized.

1977. *Decomposition of the sulphurets.*—Let the sulphuret to be examined be placed in a glass tube, and heated. The sulphurets of mercury and arsenic will sublime without decomposition; others will give off fumes of sulphur when heated, particularly the sulphurets of iron, copper, lead, and tin. The other sulphurets, and even those above mentioned, give off when heated fumes of sulphurous acid, which is immediately known by the smell, and by bleaching red litmus paper. The sulphuret of zinc gives off by this process sulphurous acid with less facility than almost any other. The sulphuret of tin becomes wholly decomposed, and the sublimate which rises is composed, not merely of sulphur, but of oxyde of tin. The sulphuret of lead changes into the sulphite of lead.

1978. *To detect the chlorides.*—On account of the dissolving action of chlorine upon platinum, a copper wire or forceps must be used with them, and owing to their very rapid decomposition by heat, they must be mixed with microcosmic salt. Suddenly heated in this way they may be known by the bright vivid color they communicate to the flame. The metallic chlorides mostly suffer reduction, but not those of the alkalis or earths. The chloride of lead sublimes as a white powder.

1979. *To detect the iodides and bromides.*—Heated with microcosmic salt and oxyde of copper, the iodides give a green flame; the bromides a blue; and heated with the bisulphate of potass in a glass tube they are decomposed, and give off vapor of iodine or bromine.

1980. *To detect the fluorides.*—When heated all the fluorides give off hydrofluoric acid; known at once by its action upon glass.

1981. *To detect the sulphates, &c.*—The sulphates, sulphites, and hyposulphites, when intensely heated, part with oxygen, and become converted into sulphurets, particularly those with an alkaline or earthy base. When fused with soda or charcoal in the reducing flame, a mass is produced which blackens metallic silver, if moist. Mixed with glass made of silica and soda, sulphates and sulphurets give under the same circumstances a deep yellowish red color, either while hot or on becoming cold.

1982. *To detect the nitrates and chlorates.*—No error can possibly be made in these salts, as when any nitrate is mixed with bisulphate of potass, and heated in a glass tube, it gives off red vapors of nitrous acid gas. The nitrates also when mixed with charcoal burst into ignition, hence their use in fireworks. The chlorates do not give off nitrous vapors, although they detonate in like manner.

1983. *To detect the borates and boracic acid.*—These are all known instantly by the peculiar color they give to the blow-pipe flame, or to alcohol in which they have been dissolved. Dr. Turner recommends that the borates should be mixed with 2 parts of a flux formed of 1 part of pulverized fluor spar, and 4½ parts of bisulphate of potass. The mixture is applied by water to the end of a wire, and held at the point of the blue flame. Soon after fusion takes place, a dark green-colored flame is seen merely for an instant. Mr. Griffin says thus, "I find the green flame of boracic acid very easily producible by dipping the borates moistened with sulphuric acid into the upper part of the blue flame. The flame is much more distinct in that position than at the point of the flame. When the borates contain soda which is very frequently the case, then the dark green flame of the boracic acid is so much affected by the yellow flame of the soda, that the color which is produced more resembles the pale green flame of baryta than it does the deep green flame of boracic acid."

1984. If minerals containing boracic acid are fused on charcoal with carbonate of potass, and then treated with sulphuric acid and alcohol, the same green flame is produced. This process is effective with black tourmaline and other minerals containing but a small quantity of boracic acid.

1985. *To detect the phosphates.*—Moisten the substance to be examined with sulphuric acid, hold it with the platinum tongs at the point of the inner flame, a green color will be given to the outer flame much paler than that of boracic acid, and greener than that produced by baryta. It is not all phosphates however which will yield this flame. A better way to analyze the phosphates is as follows:

1986. Mix with the substance twice its weight of boracic acid, fuse them together on charcoal; when in a state of fusion, drop in a particle or two of iron filings, continuing to heat the mass for some minutes, by which means a borate and phosphuret of iron will be formed; let these cool and pound them in a mortar, the phosphuret of iron will then be perceptible by its brittleness, and by being attracted by the magnet.

1987. *To detect silica.*—There are only two substances that afford a clear transparent bead of glass when melted along with soda. These are silica and titanic acid; the last is very rarely met with, therefore in such a case we may safely infer that the substance under examination is silica or flint, in fact we have by this means common glass, and whatever else is added to these ingredients, is either for the purpose of increasing its fusibility or density. Also from what we have seen it will be evident that the admixture of cobalt, nickel, silver, and other metallic oxydes to the other ingredients, will produce an article varied in color, and in opacity; hence arise the arts of coloring glass, of staining or painting on glass, and of making artificial gems. So also the action of heat upon a mixture of alumina and soda in producing an opaque mass gives rise to the whole manufacture of porcelain and enamels. The following receipts relating to these arts may be useful.

GLASS MANUFACTURE.

A glass, composed solely of silica and alkali, requires a very high temperature for its perfect fusion, and is very difficult to work; so that various substances are added with the intention of forming a more fusible, colorless, dense, and transparent compound. Oxyde of lead is very efficacious in this respect; it increases the fusibility of the compound, gives it greater tenaciousness when red hot, increases its refractive power, and enables it to bear sudden changes of heat and cold; but lead, though it confers these advantages, is productive of some evil; it renders the glass so soft that it easily scratches, and so fusible that it softens at a red heat, which though sometimes desirable is often disadvantageous in its chemical applications. Boracic acid and borax are excellent fluxes, but their high price prevents their use, except for the formation of artificial gems. Black oxyde of manganese is also often used to destroy the slight green color given with impure alkali, but is apt to communicate a purple tint, unless in very minute quantity. White arsenic and nitre are also often employed. The ingredients are first roasted at a red heat, to expel moisture and carbonic acid; they are then ground up together, when they obtain the name of ***frit***, or ***glass frit***. The glass pots or retorts are put around a furnace, which has as many furnace doors as the pots it is capable of heating. The furnace is represented beneath:—

The glass when melted is taken out on hollow iron rods, to which it readily adheres, and is then blown by the workmen into decanters, bottles, or other articles, or in the case of sheet or plate glass, it is poured, while in a melted state, on to a table prepared to receive it. The glass when cold enough to handle is carried to an oven, where it is again heated, and afterwards being allowed to cool gradually, it becomes tough, and able to bear sudden changes of temperature. It is in this state said to be annealed, and the oven to which it has been carried is called the annealing oven, and is similar to the following in appearance.

Ex. 1988. *Composition of flint glass.* (M. Loysel's.)—White sand 100 parts by weight; red lead, 80 to 85; pearl-ash, 35 to 40; nitre, 2 to 3; oxyde of manganese ½. This and the next are very soft glasses from containing so much lead.

1989. *Second receipt.* (M. Loysel's.)—White sand 100 parts; red lead 50 to 60; pearl-ash 30 to 40; oxyde of arsenic ¾ to 1. The specific gravity of this glass will not be so great as the former, in the proportion of 29 to 32, and its refractive power will evidently be smaller also.

1990. *Third receipt.* (Mr. Aikin's.)—120 parts fine white sand; 40 well-purified pearl-ash; 35 litharge or red lead; 13 nitre; and a small quantity of the black oxyde of manganese.

1991. *Composition of crown glass.*—This is the glass used for windows, &c., and is blown in round sheets; no lead or metallic oxyde is used as a flux, but a minute quantity of the black oxyde of manganese or oxyde of cobalt is sometimes added for the sake of color. This kind is therefore much harder than flint glass, and more difficult to fuse. Loysel gives the following receipt as that used at the extensive glass-works at St. Gobain:—Fine white sand 100 parts; carbonate of lime 12 parts; carbonate of soda calcined 45 to 48; clippings of crown glass, (technically called cullet,) 100 parts; together with a requisite quantity of manganese.

1992. *Second French receipt.*—100 parts white sand; 50 to 65 potass; 6 to 12 parts dry slacked lime in powder; and from 10 to 100 parts of broken glass, of similar quality. This composition is frequently employed in France for drinking vessels, as well as for window glass.

1993. *English receipts. First.*—Fine sand 5 bushels, or 200 lbs. weight; ground kelp 11 bushels, or 330 lbs.; slacked lime 15 lbs. weight, with half their weight when roasted of broken glass.

1994. *Second receipt.*—White sand 120 parts; purified pearl-ash 60; saltpetre 30; borax 2; arsenic 1 part.

1995. *Third receipt.*—White sand 120 parts; common pearl-ash 50; common salt 30; saltpetre 10; arsenic 4; and 3 drams of manganese. This is cheaper than the foregoing, and is much used for apothecaries' phials.

1996. *Fourth receipt.*—Sand 100 parts; dry sulphate of soda 50; quicklime in powder 17 to 20; charcoal 4 parts.

1997. *Composition of bottle glass.*—Common white or yellow sand 100 parts; coarse kelp 30 to 40; lixiviated potass 160 to 170; fresh wood ashes 30 to 40; yellow clay or brick earth 80 to 100; broken glass 100.

1998. *Composition of plate glass.* (Loysel.)—White sand 100 parts; carbonate of lime 12; soda 45 to 48; fragments of glass of like quality 100; oxyde of manganese ¼.

1999. *Second receipt.* (Parkes.)—Lynn sand, previously well washed and dried, 720 parts; alkaline salt, containing 40 per cent. of soda, 450 parts; lime, slacked and sifted, 80 parts; nitre 25 parts; cullet or broken plate glass 425 parts.

2000. *Third receipt.* (Thevart's.)—Fine sand 300 lb.; soda 200 lbs.; lime 30 lbs.; manganese 2 lbs.; cobalt 3 ounces; fragments of broken glass 300 lbs.

2001. *Soluble glass, silicate of potass, liquor of flints.*—This is a kind of glass which contains so much alkali as to be soluble in water. To attain this effect readily, the proportion of ingredients used may be 10 parts of pearl-ash, 15 of sand, and 4 of charcoal; one part of glass thus formed requires about 5 parts of boiling water for its solution. The solution is viscid, has an alkaline taste and re-action, and is decomposed by all acids. It has been used to wash over timber and other combustible matters to preserve them from heat; the effect of which is to fix a coating of silica upon the timber, which in some degree preserves it, yet too slightly to be of much service.

2002. *Colored glass drinking vessels, illumination lamps, smelling bottles, beads, hyacinth glasses,* and numerous other articles are made of different colors; these are given to the glass when in a melted state in the retort, by adding to their ingredients one or more of the metallic oxydes. *Blue* glass is formed by means of the oxyde of copper; *green* by the oxyde of iron; *violet* by the oxyde of manganese; *red* by the admixture of the oxydes of iron and of copper; *purple* by the purple oxyde of gold, commonly called purple precipitate of Cassius, and which is gold thrown down from its salts by tin; *white* by the oxydes of arsenic and of zinc; *yellow* by the oxyde of silver.

MAKING OF ARTIFICIAL GEMS OR PASTES.

In making artificial gems or paste jewels, the first consideration is to procure a kind of glass which shall be of as great a specific gravity, and as clear as possible, in order that it may reflect the rays of light, and occasion that particular play of light which renders paste so much more brilliant than common glass. Some glass, however, is of greater specific gravity than the gem to be imitated; were this used for the purpose the mock gem would have an unnatural glare of light, and consequently be immediately detected. Very numerous are the receipts to make the colorless *foundation paste* or *strass*, as it is called; every thing used in the making of which should be perfectly pure.

Ex. 2003. *Composition of paste for diamonds.*—Rock crystals 4056 grains; red lead 6300; pure potass 2154; borax 276; arsenic 12; or

2004. Rock crystal 3600 grains; pure carbonate of lead 8508; potash 1260; borax 360.

2005. White sand, purified by being washed first in hydrochloric and then in water till the whole of the acid is removed, 100 parts; red lead 150; calcined potass 30 to 35; calcined borax 10; oxyde of arsenic 1 part. It is necessary to keep the whole of these compounds in a state of fusion for three or four days before they will have attained their greatest perfection.

2006. *To imitate the yellow diamond.*—To 1 ounce of paste, as above, add 24 grains of the chloride of silver, or 10 grains of the glass of antimony.

2007. *To imitate the sapphire.*—To 24 ounces of paste add 2 drams 26 grains of the oxyde of cobalt.

2008. *To imitate the oriental ruby.*—To 16 ounces of paste add a mixture of 2 drams and 48 grains of the purple precipitate of Cassius; the same quantity of peroxyde of iron prepared by decomposing the nitrate of iron by potass; the same quantity of yellow sulphuret of antimony and of manganese, calcined with nitre; and 2 ounces of rock crystal, previously calcined and ground to powder; or, paste 40 grains, oxyde of manganese 1 grain.

2009. *To imitate the topaz.*—Paste 1008 grains; glass of antimony (fused oxyde) 43 grains; purple of Cassius 1 grain: or paste 100 grains; peroxyde of iron 1 grain.

2010. *To imitate the emerald.*—To 15 ounces of paste add 1 dram of blue carbonate of copper and 6 grains of oxyde of antimony; or to 1 ounce of base add 20 grains of glass of antimony, and 3 grains of oxyde of cobalt; or paste 4608 grains; oxyde of copper 42 grains; oxyde of chrome 2 grains; or, paste 9216 grains; acetate of copper 72; and peroxyde of iron 1½ grain.

2011. *To imitate the amethyst.*—Paste 4601 grains; oxyde of manganese 36; oxyde of cobalt 24; purple of Cassius 1: or paste 9216 grains; oxyde of manganese from 15 to 24; and oxyde of cobalt 1. This last receipt produces a much paler gem than the former.

2012. *To imitate the Syrian garnet or ancient carbuncle.*—Paste 256 grains; glass of antimony 128 grains; purple of Cassius 1; oxyde of manganese 1.

2013. *To imitate the beryl or aqua marina.*—Paste 1152 grains; glass of antimony 8; oxyde of cobalt ½.

2014. *To imitate the common opal.*—To 1 ounce of paste add 10 grains of nitrate of silver, 5 grains of calcined magnetic iron ore, and 26 grains of chalk.

COLORS FOR STAINING GLASS.

In staining glass the coloring ingredients are mixed with gum water, or some other fluid medium, by means of which they are spread over the surface of a plate of glass, (the glass having been previously gummed and suffered to dry,) and when dry are exposed to such a degree of heat, as by experience has been found to be sufficient. The color is then rubbed off from the surface of the glass to which it does not adhere; and those parts of the plate which have been thus covered are found to have acquired a permanent stain, owing to some of the color having been absorbed and fixed in the pores of the glass.

Ex. 2015. *Flesh color.*—Take an ounce of red lead, 2 ounces of red enamel, (Venetian glass enamel, from alum and copperas calcined together,) grind them to fine powder, and work this up with spirits, (alcohol,) upon a hard stone. When slightly baked, this produces a fine flesh color.

2016. *Black color.*—Take 14½ ounces of smithy scales of iron, mix them with 2 ounces of white glass, (crystal,) an ounce of antimony, and ½ an ounce of manganese; pound and grind these ingredients together with strong vinegar. A brilliant black may also be obtained by a mixture of cobalt blue with the oxydes of manganese and iron. Another black is made from 3 parts of crystal glass, 2 parts of oxyde of copper, and 1 of (glass of) antimony worked up together, as above.

2017. *Brown color.*—An ounce of white glass or enamel, ½ an ounce of good manganese; ground together.

2018. *Red, rose, and brown colors*, are made from peroxyde of iron, prepared by nitric acid. The flux consists of borax, sand, and minium in small quantity.

2019. *Red color* may be likewise obtained from 1 ounce of red chalk pounded, mixed with 2 ounces of white hard enamel, and a little peroxyde of copper.

2020. *A red* may also be composed of rust of iron, glass of antimony, yellow glass of lead, such as is used by potters (or litharge) each in equal quantity; to which a little sulphuret of silver is added. This composition, well ground, produces a very fine red color on glass. When protoxyde of copper is used to stain glass, it assumes a bright red or green color, according as the glass is more or less heated in the furnace, the former corresponding to the orange protoxyde, the latter having the copper in the state of peroxyde.

2021. *Bistres and brown reds* may be obtained by mixtures of manganese, orange oxyde of copper, and the oxyde of iron, called umber, in different proportions. They must be previously fused with vitreous solvents.

2022. *Green color.*—2 ounces of brass calcined into an oxyde, 2 ounces of minium, and 8 ounces of white sand; reduce them to a fine powder, which is to be inclosed in a well-luted crucible, and heated strongly in an air-furnace for an hour. When the mixture is cold, grind in a brass mortar. Green may, however, be advantageously produced by a yellow on one side, and a blue on the other. Oxyde of chrome has been also employed to stain glass green.

2023. *A fine yellow color.*—Take fine silver laminated thin, dissolve in nitric acid, dilute with abundance of water, and precipitate with solution of sea salt. Mix this chloride of silver, in a dry powder, with three times its weight of pipe-clay well burnt and pounded. The back of the glass pane is to be painted with this powder; for when painted on the face it is apt to run into the other colors.

2024. *Another yellow* can be made by mixing sulphuret of silver with glass of antimony and yellow ochre, previously calcined to a red-brown tint. Work all these powders together, and paint on the back of the glass; or silver leaf, melted with sulphur and glass of antimony, thrown into cold water, and afterwards ground to powder, afford a yellow.

2025. *A pale yellow* may be made with the powder resulting from brass, sulphur, and glass of antimony, calcined together in a crucible, till they cease to smoke, and then mixed with a little burnt yellow ochre.

2026. *The fine yellow* of M. Merand is prepared from chloride of silver, oxyde of zinc, white clay, and rust of iron. This mixture, simply ground, is applied on the glass.

2027. *Orange color.*—Take 1 part of silver powder, as precipitated from the nitrate of that metal by plates of copper, and washed; mix it with 1 part of red ochre and 1 of yellow, by careful trituration; grind into a thin pap with oil of turpentine or lavender, and apply this with a brush, dry, and burn in.

ENAMELS.

Process of enamelling.—Enamels are of different colors and opaque, and may be considered as intermediate between glass and porcelain. They are applied to the surface of copper, iron, or gold, to which they firmly adhere. The formation of enamels was once an art of considerable extent; it is now chiefly applied to the covering of the dials of clocks and watches; the white enamel for which is usually purchased by the enameller ready formed, his trade consisting in the applying it to the surface of the metal; enamel of all colors coming principally from Italy. The process of applying enamel to a surface is very simple. The enamel of proper color is ground to powder, mixed with water, and applied by a brush to the surface, either as a uniform color, or as a various-colored painting. The under surface of the metal is also covered in like manner with an inferior enamel that it may not crack in drying, both sides being covered they heat and cool equally one with the other. The enamel is now suffered to dry, and when dry the plate is suspended either on a ring which merely touches the edge, or else on some points of wire. Thus supported, it is placed within a muffle in a furnace, and made gradually hot until the enamel is seen to melt evenly over the surface. When this is the case, the plates are suffered to cool very gradually, when they are finished as far as that color, or those colors, are concerned. Other colors may, however, afterwards be put on. The artist observing to lay on first that which requires the greatest heat, and afterwards those which require a less temperature. The ground color is usually mixed with water, but the colors afterwards laid on are preferably mixed with oil of spikenard or oil of lavender.

2028. *Composition of white enamel.*—Neri, in his valuable treatise on glass-making, has long ago given the following proportions for the common material of all the opaque enamels, which Kunckel and other practical chemists have confirmed:—Calcine 30 parts of lead with 33 of tin, keeping the whole calcined mass red hot, till no more flames arise from it; and until it is of a greyish white uniform color. Take of this calcined mixed oxyde, 50 pounds, and as much of powdered flints, (prepared by being thrown into water when red hot, and then ground to powder,) and 8 ounces of salt of tartar; melt the mixture in a strong fire, kept up for 10 hours; after which reduce the mass to powder. This is the common material for opaque enamels, and is of a grey color. To make this enamel of a pure white, mix 6 pounds of the compound with 48 grains of the best black oxyde of manganese, and melt in a clear fire. When fully fused, throw it into cold water; then re-melt and cool as before, three or four times, till the enamel is quite white and fine.

2029. *Paste for colored enamels.*—These are usually more transparent than the white enamel, and require a different mixture of materials. The base for all of them may be 3 parts of silicious sand, 1 of chalk, and 3 of calcined borax; or 3 of broken flint glass, 1 of calcined borax, ¼ of a part of nitre, and

1 part of antimoniate of potass, made by deflagrating antimony and potass together. This is also a white enamel, but being without lead is better adapted to give a pure tint with the metallic oxydes used.

2030. *Blue enamel.*—This fine color is always produced by the oxyde of cobalt, a very minute quantity of which is added to the white enamel last recommended. Cobalt is best used in the state of the arseniate; the heat decomposing the arseniate, deposits and incorporates the cobalt with the ground color, while the arsenic acid, which communicates of itself no color, partly flies off and partly acts as a flux. A small quantity of nitre is a useful addition, and tends to bring out a finer color.

2031. *Red enamel.*—Add to the white enamel a small portion of pure protoxyde of copper, which should be of a red color. This pure oxyde used by itself furnishes a color to the enamel equal to the finest carmine, and by its means every tint may be obtained from red to orange, by adding more or less of the peroxyde of iron. The preparations of gold, and particularly the oxyde and purple of Cassius, are likewise employed with advantage to color enamel red, and this composition resists a powerful fire moderately well. For some time past, solutions of gold, silver, and platinum, have been used with success, instead of their oxydes, and in this a more intimate mixture may be procured, and consequently more homogeneous tints.

2032. *Yellow enamel.*—This is very uncertain to tint and clearness. It may be made by painting over a white enamel with the oxyde of silver, mixed with oil of lavender, and submitted to heat; or by adding to the white enamel a small portion of 3 parts carbonate of lead, 1 part oxyde of antimony, 1 part alum, and 1 of sal ammoniac. Nitre as a flux is injurious.

2033. *Green enamel.*—To 4 pounds of frit, (white enamel,) add 2 ounces of the deutoxyde of copper and 48 grains of peroxyde of iron; or, instead of the oxydes of copper and iron, substitute an equal quantity of oxyde of chromium. A grain or two of oxyde of cobalt usually improves the color by rendering it darker; when used alone it is most frequently of a yellowish green, though this depends chiefly upon the management of the fire. The color produced by the copper and iron is dark enough of itself, and is darker or lighter in proportion to the relative quantity of iron.

2034. *Black enamel.*—Add to the frit before mentioned a small portion of the oxyde of manganese and cobalt, or the protoxyde of iron and cobalt. Clay alone, melted with about one-third of its weight of protoxyde of iron, gives, according to Claudet, a black enamel.

2035. *Violet enamel.*—Use the peroxyde of manganese in very small quantity, according to the shade required.

These receipts are given, as if it were required to make rods or lumps of enamel, for the making of beads and artificial eyes, and other articles, rather than enamel painting. In the latter, the surface or ground is laid on in white enamel and burnt in. The landscape or other subject to be represented is then painted upon the surface with the coloring matter, mixed with essential oil, as in painting upon or staining glass, and the various colors then burnt in by several firings, according to the different degrees of heat required to produce the wished-for shade, a knowledge of which only experience will give.

GLASS BLOWING.

There is another art, closely in connection with this, practised in large cities, and in which very considerable taste and judgment is exercised; namely, the making of ornamental articles in plain and colored glass, by means of a table blow-pipe. Thus the most beautiful objects in the shape of swans and other animals, baskets, candlesticks, ships, &c., may be easily made; and not only so, but the experimental chemist will find such an apparatus of most essential use in the manufacture of test, thermometer, and other tubes, small retorts, and numberless other articles of a similar kind, and as the table blow-pipe is of easy construction, and these articles necessary in the laboratory, we will give a description of it, and some hints on the mode of using.

A is a jet of metal, through which the air issues into the flame of the lamp B. The air is by means of the treadle E forced into the double bellows D, and driven up the pipe C until it issues from the jet. The whole is affixed to a table covered with lead. The bellows is loaded at the top in proportion to the strength of the blast required.

2036. *Bordering and widening glass tubes, &c.*—By bordering glass tubes is meant the slight melting of their edges, in order to render them smooth and even. To do this, let the tube be held withinside the point of the flame, and quickly turned round, so as to heat the whole edge equally. When it has thus been made red hot the operation is finished; should it get out of shape, an iron rod or wire placed within it, and pressed against the depressed side, will quickly restore it to its proper shape. If the end is to be contracted, roll the end of the tube, (holding it in a slanting direction,) on the leaden top of the table. If not flat at the top, press the heated end perpendicularly upon the table, and if the edges are to be widened out, press the iron rod against them in the inside, turning the tube round at the same time; by heating the tube more than once, if required, any degree of expansion or contraction may be given to the edges. A dark red heat is sufficient for this operation.

2037. *Drawing out and contracting tubes.*—If the tube is to be contracted, and drawn out in the middle, hold it at each end by the hands, and turn it round continually and uniformly, until of a cherry-red heat. Then taking it from the flame draw the hands more asunder, which will, at the same time, elongate and contract the tube, so as to make a thin tube in the middle of the thick one; care must be taken to keep the whole straight. To elongate and contract the extremity, heat it as before; and seizing the extremity with a pair of plyers, draw it out steadily and more or less rapidly, according to the size of the small tube required. When you desire to draw a point from the side of a tube, you must heat that portion alone, by holding it fixedly at the extremity of the jet of flame. When it is sufficiently heated hold in the flame, by the other hand, a small rod of glass, and when this is hot, stick it to the part of the tube heated. Then drawing the small rod outwards, it will bring with it the side of the tube which has been softened, and draw it out into a distinct and smaller orifice.

2038. *Choking or contracting the diameter of a tube.*—Bring the part to a red heat; then draw the tube out slightly, which will contract it at the heated part; then pressing it close again, the tube will be contracted without being elongated.

2039. *Sealing or closing a tube.*—Bring the tube which is to be closed at the end to a red heat; then if the sides be thin, and the tube small, the glass sinks of itself towards the axis of the tube, and becomes rounded. If the tube be of considerable diameter, or if the sides are thick, you must soften the end, and then with a metallic rod, or a flat pair of plyers, mould the sides to a hemisphere, by bringing the circumference towards the centre, and continuing to turn the tube in the flame, until the extremity is well rounded, and completely closed. If it is to be hollow beneath, like the bottom of a large phial, the glass while yet hot may be pressed inwards by a metal rod.

2040. *Blowing bulbs, &c.*—To blow a bulb at the extremity of a tube you commence by sealing it, after which you collect at the sealed extremity more or less glass according to the size and solidity you desire to give the bulb. This being done, heat the extremity in the flame until the whole mass there collected be of a white heat. Then blow into the open end of the tube, which will give to the mass of fluid glass the desired globular form. If not large enough, it must be heated, and blown again. During the whole operation the tube must be kept constantly turned round, or the bulb will be distorted. The tube must be removed from the flame before it is blown into.

2041. *Bending glass tubes.*—If you desire a sudden bend you heat only a small portion of the tube to a dull red heat, and bend it with the hand held at the opposite ends. If the bend is to be gradual you must heat an inch or two of it in length, previous to bending it. If you require a gradual bend on the one side, and a sharp one on the other as in retorts, a little management of the tube in the flame, moving it to the right and left alternately at the same time, that it is turned round, will easily form it of that shape. In bending glass, the part which is to be concave is to be the most heated. An ordinary gas flame is quite sufficient to bend glass by.

POTTERY AND PORCELAIN.

As seen above, the property of silica is in all cases to produce a transparent mass when melted with pearl-ash; and although the admixture of metallic oxydes is in some instances used to color, and in others to render the mass opaque, yet it is but glass, and is known as such by becoming soft each time that it is brought to the same heat which first formed it; in that respect it differs from every species of pottery and earthenware, the base of which is at all times alumina, though silica is generally added to produce the requisite degree of transparency in certain articles, still it is to be observed, that although this admixture of glass produces certain desirable properties, yet it produces inconveniences from which alumina alone is free; particularly in those articles in which the silica preponderates are not so well adapted to bear sudden changes of temperature as those made with pure clay only; and even the gloss upon articles of earthenware is often seen to crack off while the article itself remains whole and otherwise uninjured, yet clay alone contracts much in the fire during the process of burning, hence a silicious substance is necessary. The common red pottery ware, and also bricks and tiles, are made of common clay mixed with a portion of sand. For delph or common white ware, stone ware, tobacco pipes, &c., a fine white clay is procured from Devonshire and Dorsetshire; this is mixed with water to a thin paste, ground flint is also mixed with water to the same consistence. These pastes are then mixed together, and when dry enough to work are made into the various vessels; these are suffered to dry so that they may be handled, then placed in a kiln and burnt to hardness. In this state they are called biscuit china, and are without gloss; the gloss or glaze is then laid on either with a brush, or by dipping the article in the tub of glaze, and again burnt to vitrify. The colors are then laid on and burnt in by another operation, or in the case of common goods the whole are burnt together by one operation.

Ex. 2042. *Glaze for common white ware.*—Litharge and ground flints in the proportion of 10 parts by weight of the former to 4 parts of the latter. Cornish granite is sometimes used instead of the flints in the proportion of 8 parts by weight to 10 of litharge.

2043. *Mr. Rose's glaze for printed ware.*—27 parts of felspar, 18 of borax, 4 of Lynn sand, 3 of nitre, 3 of soda, and 3 of the china clay of Cornwall; the ingredients are melted together and ground to a fine powder. This is is used for figured blue ware, and is called printing frit.

2044. *Glaze for painted ware and porcelain.*—Take 13 parts of the last frit and add to them 50 parts of red lead, 40 of white lead, and 12 of flint, the whole having been ground together.

2045. *Glass for red ware.*—Common salt 13 parts, carbonate of potass 30 parts, dissolve them in water and dip the article in the glaze.

2046. *Colors for porcelain.*—Manganese produces the dark *purple* color. Gold precipitated by tin a *rose* color; antimony *orange;* cobalt different shades of blue, copper is employed for the browns and dead-leaf greens. Nickel and umber for fine browns, and nickel along with potass for greens.

2047. *Composition of Wedgewood mortars.*—6 parts clay, 3 felspar, 2 flint, and 1 china clay, burnt without glazing.

2048. *Composition of crucibles.*—Fire clay or Stourbridge clay 1 part, coarse but pure sand 3 parts. There being no flux, they require a very strong heat in the baking, and will afterwards bear an intense temperature unchanged by acid or even metallic substances placed within them, unless such metallic bodies act as fluxes; such as those of lead, antimony, or arsenic, when they will vitrify, or when saline fluxes are used to assist in the fusion of their contents. The strongest crucibles contain no sand, coarse black lead in powder, or brick-dust being used instead of it.

CHAP. IX.

APPLICATION OF CHEMISTRY.

The applications of chemistry are extremely numerous; so numerous indeed that scarcely an art or manufacture of any kind can be conducted without its aid. We have already described a multitude of processes, wholly dependent upon its principles. To the medical practitioner it is evidently of essential value, particularly in compounding medicines, that he may not mix together *incompatibles*, or substances which destroy each other; that he may be able to analyze unknown medicines; that he may detect the presence, and obviate the effect of poison; that he may know the chemical structure of organic matters, particularly of the living human body; and particularly that he may anticipate the effect which chemical matters may have upon it, both in a state of health or of disease. The soap maker, distiller, tanner, bleacher, dyer, and other manufacturers, are no less beholden to this art for the very existence of their various trades; yet for all this their processes depend upon a single chemical fact. The soap maker owes all his manufacture to the simple fact, that alkalis dissolve fatty substances when assisted by heat. The distiller's business depends upon the knowledge that when two or more liquids are boiled together, the lighter of them rises in vapor before the other. Tanning may be explained by a single experiment. Bleaching and dyeing, and the making of varnishes, though more extensive, are nearly as simple. Etching and lithography, and other processes of the fine arts, depend entirely upon one or two facts. All that can be said about these processes, therefore, that can be truly be called chemical, is the explanation of the solitary facts upon which they depend ; yet this alone would convey, if not a useless, at least a very inadequate idea of their extent and importance. We shall, therefore, treat of these and other chemical arts in the same manner as we have already of fire-works in page 150 ; inks in page 186 ; the glass manufacture in page 230 ; and the working in plaster in page 157.

MANUFACTURE OF SOAP.

Soap is a chemical compound of fatty substances with alkalis. These substances thus treated undergoing remarkable changes, and being converted into three acids, called the margaric, stearic, and oleic ; these uniting with the alkali form the neutral compound known as soap, and which is hard or soft, according to the materials employed ; the former being produced by the action of soda, the latter by that of potash.

Ex. 2049. *Hard white or curd soap.*—The fat of this soap may be either tallow or coarse oil. The crude soda or barilla is ground, and placed in cylindrical vats, with alternate layers of quicklime. Water being poured upon the whole, it passes through the mass, and dissolves the soda, at the same time that the lime absorbs the carbonic acid. This caustic liquid being drawn off, 200 gallons of it, of the specific gravity of 1·040, are added to a ton of tallow ; heat is applied, and after a very gentle ebullition of about four hours, the fat will be found to be completely saponified, by immersing in it a knife, for the fluid lye will be seen to separate at once upon the steel blade from the soapy paste. When thus perfected it is poured into square frames, where it is suffered to cool ; when cool, it is cut in the required and usual form of long square cakes, and is ready for sale as soon as the cakes have been exposed to the air for a few days to harden.

2050. *Hard mottled soap.*—Mottling is usually given in the London soap works by introducing into the nearly-finished soap, in the pan, a certain quantity of the strong lye of crude soda, without lime, through the rose spout of a common watering can. This lye contains much sulphur, and in descending through the pasty mass occasions the marbled appearance. In France a small quantity of solution of sulphate of iron, sprinkled over in like manner, is more commonly employed. The alkali seizes the acid of the sulphate, and sets the protoxyde of iron free, to mingle with the paste, to absorb more or less oxygen, and thus to occasion a variety of colors. When the oxyde passes into the red state, it gives the tint called *manteau Isabelle.* Three pounds of olive oil afford 5 pounds of marbled Marseilles soap of good quality, and only 4¼ of white soap, showing that more water is retained by the former than by the latter. Thus for washing, &c., white soap at 6*d.* per lb. is as cheap as mottled soap at 5*d.*

2051. *Yellow or rosin soap.*—Resinous substances, (except one or two,) are not converted into acids by the action of alkalis ; hence do not of themselves form soaps, but when united with an equal quantity or more than this of grease, the whole blends together, and forms the ordinary yellow soap of the shops. A hard and very common soap is made, as just described, and in the last stage of the boiling process the adequate quantity of pounded rosin is added. The union of this, however, with the alkali is not perfect, consequently the soap when used is more decomposed by the hot water, and the alkali to some degree liberated. This, therefore, acts directly upon the greasy dirt of foul clothing, &c., and removes it with greater facility ; for which reason this soap is much used in manufactures, and is also preferred by laundresses, who not content with the detergent properties of the soap are accustomed to add carbonate of soda to the water employed.

2052. *Soft soap.*—The principal difference between soaps with base of soda, and soaps with base of potash, depends upon their mode of combination with water. The former absorb a large quantity of it, and become solid ; they are chemical hydrates. The others experience a much feebler cohesive attraction ; but they retain much more water in a state of mere mixture. From its superior solubility, more alkaline reaction, and lower price, potash soap is preferred for many purposes, and especially for scouring woollen yarns and stuffs.

Soft soaps are usually made in this country with whale, seal, olive, and linseed oils, and a certain quantity of tallow; on the continent, with the oils of hempseed, sesame, rape-seed, linseed, poppy-seed, and colza; or with mixtures of several of these oils. The potash lyes should be made perfectly caustic and of at least two different strengths; the weakest being of specific gravity 1·05; and the strongest, 1·20, or even 1·25. A portion of the oil being poured into the pan, and heated to nearly the boiling point of water, a certain quantity of the weaker lye is introduced; the fire being kept up so as to bring the mixture to a boiling state. Then some more oil and lye are added alternately, till the whole quantity of oil destined for the pan is introduced. The ebullition is kept up in the gentlest manner possible, and some stronger lye is occasionally added, till the workman judges the saponification to be perfect. The boiling becomes progressively less tumultuous, the frothy mass subsides, the paste grows transparent, and gradually thickens. The operation is considered to be finished when the paste ceases to affect the tongue with an acrid pungency, when all milkiness and opacity disappear, and when a little of the soap placed to cool upon a glass-plate assumes the proper consistency.

2053. *Soft toilet soaps.*—Its manufacture being conducted on the principles already laid down presents no difficulty to a man of ordinary skill and experience; the only point to be strictly attended to is the degree of evaporation, so as to obtain soap always of uniform consistence. The fat generally preferred is good hog's lard; of which 30 pounds are to be mixed with 45 pounds of a caustic lye; the temperature is to be gradually raised to ebullition, but the boil must not be kept up too long, or too briskly till after the saponification is completed, and the whole of the lye intimately combined with the fatty particles; after this, the evaporation of the water may be pushed pretty quickly, by a steady boil, till copious vapors cease to rise. This criterion is observed when the paste has become too stiff to be stirred freely. The soap should have a dazzling snowy whiteness, provided the lard has been well refined, by being previously triturated in a mortar. melted by a steam heat, and then strained. The lard soap so prepared is semi-solid, and preserves always the same appearance, If the paste is not sufficiently boiled, however, it will show the circumstance very soon; for in a few days the soap will become gluey and stringy, like a tenacious mass of birdlime. This defect may not only be easily avoided, but easily remedied, by subjecting the paste to an adequate evaporation. Such soaps are in great request for shaving, and are most convenient in use, especially for travellers. Hence their sale has become very considerable.

2054. *Pearl soft soap.*—It is only a few years since the process for making this elegant soap became known in France. It differs little from the preceding, and owes its beautiful aspect merely to minute manipulations, about to be described. Weigh out 20 pounds of purified hog's lard on the one hand; and 10 pounds of potash lye at 36° B. on the other. Put the lard into a porcelain capsule, gently heated upon a sand-bath, stirring it constantly with a wooden spatula; and when it is half melted, and has a milky appearance, pour into it only one-half of the lye, still stirring, and keeping up the same temperature, with as little variation as possible. While the saponification advances gradually, we shall perceive, after an hour, some fat floating on the surface, like a film of oil, and at the same time the soapy granulation falling to the bottom. We must then add the second portion of the lye; whereon the granulations immediately disappear and the paste is formed. After conducting this operation during four hours, the paste becomes so stiff and compact, that it cannot be stirred; and must then be lightly beaten. At this time the capsule must be transferred from the sand-bath into a basin of warm water, and allowed to cool very slowly. The soap, though completely made, has yet no pearly appearance. This physical property is developed only by pounding it strongly in a marble mortar; whereby all its particles, which seemed previously separated, combine to form a homogeneous paste. The perfume given to it is always essence of bitter almonds; on which account the soap is called *almond cream, crème d'amandes.*

2055. *Real Castile soap* is composed of soda 9 parts, oily fat 76·5 and water 14·5; but it is not made by these proportions of ingredients, because of the alkali employed being in an impure state. Thus supposing common barilla be used, it will in all probability require half as much weight of barilla as the fat required. For the white curd soap it may require one-third part by weight of crude alkali, and as this seldom contains more than 20 per cent. of real pure soda, it reduces the quantity of alkali in the soap, when complete, to from 6 to 10 per cent.

2056. *English imitation of Castile soap.*—Soda 10 parts, oily fat 75, water, &c., 14·3. It is seen that this contains rather more alkali than the former.

2057. *Marine soap.*—This soap possesses the peculiar property of forming a good lather with sea water; hence its name. It is made by boiling together soda lye with cocoa nut oil. It contains an immense quantity of water; its composition when complete being soda 4·5, oil 22, water 73·5 in every hundred parts.

2058. *Windsor soap.*—Take common hard curd soap 56 lbs., oil of carraway 1½ lb., tincture of musk 12 ounces, English oil of lavender 1 ounce, and oil of marjoram 4 drams.

2059. *Starkey's soap.*—Rub together in a mortar subcarbonate of potass with oil of turpentine.

2060. *Soap à la rose.*—This is made of the following ingredients:—30 pounds of olive-oil soap; 20 of good tallow soap. Toilet soaps must be reduced to thin shavings, by means of a plane, with its under face turned up, so that the bars may be slid along it. These shavings must be put into an untinned copper pan, which is surrounded by a water-bath, or steam. If the soap be old and hard, 5 pounds of water must be added to them; but it is preferable to take fresh-made soaps, which may melt without addition, as soap some time kept does not readily form a homogeneous paste. The fusion is commonly completed in an hour, or thereby, the heat being applied at 212° Fah., to accelerate the process, and prevent the dissolution of the constituent water of the soap. For this purpose the interior pan may be covered. Whenever the mass is sufficiently liquefied, 1½ ounces of finely ground vermillion are to be introduced, and thoroughly mixed, after which the heat may be taken off the pan; when the following perfumes may be added with due trituration:—3 ounces of essence of rose; 1 ditto cloves; 1 ditto cinnamon; 2½ ditto bergamot.

2061. *Soap au bouquet.*—30 pounds of good tallow soap; 4 ounces of bergamot; oil of cloves, sassafras, and thyme, 1 ounce each; neroli, ½ ounce. The color is given with 7 ounces of brown ochre.

2062. *Cinnamon soap.*—30 pounds of good tallow soap; 20 ditto of palm-oil soap. Perfumes:—7 ounces of essence of cinnamon: 1¼ ditto sassafras; 1¼ ditto bergamot. Color:—1 pound of yellow ochre.

2063. *Orange-flower soap.*—30 pounds of good tallow soap; 20 ditto palm-oil soap. Perfumes:—7½ ounces essence of Portugal; 7½ ditto amber. Color:—9½ ounces, consisting of 8¼ of a yellow-green pigment, and 1¼ of red lead.

2064. *Musk soap.*—30 pounds of good tallow soap; 20 ditto palm-oil soap. Perfumes:—Powder of cloves, of pale roses, gilliflower, each 4½ ounces; essence of bergamot, and essence of musk, each 3½ ounces. Color:—4 ounces of brown ochre, or Spanish brown.

2065. *Bitter almond soap.*—Is made by compounding, with 50 pounds of the best white soap, 10 ounces of the essence of bitter almonds.

2066. *Transparent soaps.*—These soaps were for a long time manufactured only in England, where the process was kept a profound secret. They are now made every where. Equal parts of tallow soap, made perfectly dry, and spirit of wine, are to be put into a copper still, which is plunged in a water-bath, and furnished with its capital and refrigeratory. The heat applied to effect the solution should be as slight as possible, to avoid evaporating too much of the alcohol. The solution being effected, must be suffered to settle; and after a few hours' repose, the clear supernatant liquid is drawn off into tin frames, of the form desired for the cakes of soap. These bars do not acquire their proper degree of transparency till after a few weeks' exposure to dry air. They are now planed, and subjected to the proper mechanical treatment for making cakes of any form. The soap is colored with strong alcoholic solution of archil for the rose tint, and of turmeric for the deep yellow. Transparent soaps, however pleasing to the eye, are always of indifferent quality; they are never so detergent as ordinary soaps, and they eventually acquire a disagreeable smell.

MANUFACTURE OF PIGMENTS.

Whites.

2067. *Constant white, Hume's permanent white, Derbyshire white.*—This is the purified sulphate of baryta, and is usually made from the crude native carbonate, as follows:—First, having pounded the rough carbonate, roast it in a hot fire for half an hour or more to drive off the carbonic acid; then add nitric acid, which will dissolve the baryta, forming of course the nitrate. This is to be filtered off from any dregs which remain. To the filtered solution then add dilute sulphuric acid, or a solution of the sulphate of soda; stir them well together, and the sulphate of baryta falls to the bottom; this after being carefully washed with water to separate any free acid will be the pigment required. It is valuable to label the jars in laboratories as it is affected by few substances.

Pearl white. See *Ex.* 110, 1258.

Dutch ceruse, flake white. See *Ex.* 1405.

White lead or ceruse. See *Ex.* 1403.

Krem's white. See *Ex.* 1406.

2068. *Morveau's white.*—Dissolve cream of tartar in water, and add lime water as long as a precipitate falls down. Wash and dry.

2069. *Kemp's white.*—To crude carbonate of baryta add hydrochloric acid, which will dissolve it. Then filter and add to the filtered solution, subcarbonate of ammonia, to precipitate the white. Wash and dry in cakes for use. This pigment is therefore precipitated carbonate of baryta.

2070. *Spanish white.*—Powdered chalk.

2071. *Baum's alum white.*—Roman alum 1 lb. honey ½ a pound; dry, powder, and calcine in a shallow dish to whiteness, wash and dry; a beautiful white even with oil.

Blacks.

Ivory black. See *Ex.* 340.

Lamp black. See *Ex.* 339.

Indian ink. See *Ex.* 1640.

Browns and Yellows.

2072. *Asphaltum, bitumen, mineral resin, Jew's pitch.*—This is a natural product collected on the surface of the lake Asphatites. (The Dead Sea.) The resin as imported has been subjected to no preparation beyond that of melting. The liquid asphaltum as used by the English and Italian painter is prepared by dissolving the pitch in oil of turpentine; in this state it is thick, and is known as the best *Brunswick black varnish.* It is used to put a fine black gloss upon iron work. It is not however adapted for stopping out defects in plates which are etched, nor for the oil painter until it has been mixed with mastic varnish, to prevent its spreading and flowing off the palette. The French prepare it by melting together 60 grains of gum lac and 15 grains of Venice turpentine. When melted, the asphaltum, to the amount of 90 grains, is added a little at a time; 240 grains of linseed oil, heated to nearly the boiling point, is then added, and mingled by degrees with the rest; last of all 30 grains of white wax are added to the rest of the ingredients. This preparation, inclosed in a tin tube, will keep fluid for a long time.

2073. *Cologne earth and Cassel earth.*—These are bituminous earths, originating as it is supposed from the decomposition of wood. The Cassel earth has the greatest quantity of bitumen; it is prepared in the same manner as asphaltum, and is subject to the same inconvenience, namely, not drying without great difficulty.

2074. *Bistre.*—This is the soot deposited from wood fires, particularly from resinous woods. The best concretes in the chimney in the state of little balls, like peas. These, (and the soot itself for commoner qualities,) are collected and ground in oil or water, according as it is required as a water color or an oil color; for the latter, however, it is seldom used.

2075. *Mummy brown.*—The bituminous substance found in and enveloping Egyptian mummies; it may be considered partly animal and partly bituminous matter.

2076. *Sepia.*—This fine water color is the produce of the cuttle fish, and is that brown liquid which the animal ejects to darken the water when pursued by enemies. One part of it is capable of making 1000 parts of water nearly opaque. The *sepia officinalis* is sought for in the Mediterranean, where it is abundant. Its bag of liquid is extracted, the liquid poured out, and dried as quickly as possible. The dried native sepia is prepared for the painter by first triturating it with a little caustic lye; then adding more lye, boiling the liquid for half an hour, filtering, next saturating the alkali with an acid, separating the precipitate, washing it with water, and finally drying it by a gentle heat.

2077. *Umber.*—This mineral is of the nature of the ochres, but more transparent. It is a combination of oxyde of manganese, oxyde of iron, silex, and alumina. This color becomes much darker and finer by calcination. It dries rapidly, and has a good body, but becomes darker by age.

2078. *Vandyke brown.*—This is a bituminous and vegetable mass extracted from the lower stratum of peat bogs.

2079. *Terra Sienna.*—A yellowish brown earth, brought chiefly from Italy, and a favorite color with water-color painters. It becomes of a very fine reddish brown when calcined.

2080. *Ochres.*—The ochre colors are red, brown, or yellow. Their coloring principle is at all times iron, in the state of the peroxyde. The chief of these are Terra Sienna just mentioned, Spanish brown, Indian red, Venetian red, Roman ochre, red and yellow ochres, (English productions,) stone ochre, Italian ochre, Lemnian earth, mahogany earth, ruddle, and hard ruddle, or red chalk.

Chrome yellow. See *Ex.* 112.

Patent yellow, or mineral yellow. See *Ex.* 930, 931.

Orpiment, realgar. See *Ex.* 1025.

Massicot and litharge. See *Ex.* 676.

2081. *Naples yellow.*—This is a combination of the oxydes of lead and antimony, made as follows —Reduce to powder and mix together, 12 ounces of white lead, 2 ounces oxyde of antimony, ½ an ounce of salt of tartar, and 1 of sal ammoniac. When mixed they are to be placed in an earthen pan, covered with a lid of the same material. This pan is then to be placed in a potter's furnace, where it is to be calcined; first, at a low heat, increasing it by degrees till the vessel has assumed a moderately red appearance; it will require three hours of this calcination. The product of this operation will be a fritty substance, of a golden yellow hue. This frit is then thrown in water, to separate it from whatever salts it may contain; it is then ground, and its tint becomes much paler.

Kermes yellow, or Kermes mineral. See *Ex.* 1023.

2082. *Queen's yellow.*—Boil together 5 parts by weight of sulphuric acid and 4 of mercury; a white crystalline persulphate of mercury is obtained. This when thrown into water undergoes decomposition, being resolved into a soluble supersulphate, and an insoluble subsulphate, which is precipitated, forming, when washed and dried, Queen's yellow. It is far from being a permanent pigment.

2083. *Gamboge.*—The resin of the *Stalagmites gambogioides*, a tree of Ceylon and Cochin China. It is usually in the state of rounded masses or rolls; it has no smell and but little taste. It leaves however a very peculiar feeling in the throat. It is used without any preparation as a water color.

2084. *Indian yellow.*—A fine deep yellow color, but one which is not permanent. It is a urophosphate of lime. Its composition being the uric acid, phosphoric acid and lime, with sometimes the addition of hydrochlorate of ammonia. It is used chiefly as a water color.

Reds and Orange.

Orange chrome, chrome red. See *Ex.* 1467, 1468, 1471.

Light red, a kind of ochre. See *Ex.* 2080.

Red red, minium. See *Ex.* 680.

Vermillion. *Ex.* 1029.

Geranium color, intense scarlet. See *Ex.* 980.

2085. *Carmine.*—This rich crimson is a combination of the most brilliant portion of the coloring matter of cochineal united to some animal matter fixed upon an acid basis. There are various ways of preparing this color, and many receipts have been published; but all these are resolved into the following:—A pound of cochineal, in powder, is boiled in river or rain water, and to dissolve the coloring matter 4 or 5 drachms of subcarbonate of soda and potass are added; this liquor having boiled for a quarter of an hour, 8 or 10 drachms of alum in powder are thrown into it, and it is stirred well with a spatula or large brush; the vessel is then to be taken from the fire, and allowed to remain quiet for half an hour; the liquid is then drawn off clear into very clean saucers, and well covered up, to prevent dust getting in; at the end of seven or eight days, the water being drawn off, the carmine is found deposited at the bottom of each saucer, and when dry is fit for use.

2086. *Lake, or carmine lake.*—This name was originally given to designate merely the purplish color called crimson, and when employed alone it always bears that appellation; but in its more extended sense it is applied to all colors prepared by combining a coloring matter or tincture with a basis, which is commonly alumine; hence we have yellow, green, and violet lake.

Preparation.—The manufacturers commence the preparation by preparing that which is called "the white body of lake," which is composed of a paste of pure alumine, or of alumine and chalk, upon which the coloring matter being thrown, fixes itself in a manner more or less durable. To prepare this paste, a quantity of alum is to be dissolved in water; and this solution is then precipitated by subcarbonate of soda or potass, in the proportion of 3 parts of good potass to 5 of alum. (Soda is preferable for this purpose; 4½ parts of this material are required to saturate 5 parts of alum.) It is easy to ascertain whether the whole of the alumine is precipitated without an excess of alkali; when the precipitate has fallen to the bottom of the vessel, some of the clear liquid should be drawn off into two glasses; into one of these is thrown some drops of a solution of potass, and into the other a little alum water. If the precipitation is perfectly formed, no other subsidence will take place in either of the glasses; when the sediment is formed, the liquid is to be drawn off, and the deposit is to be washed with a great quantity of water, until at last it comes off without smell; it is then extended upon a filter of linen to drain, and when it is of the consistence of soft paste, it must be mixed with a warm decoction of cochineal, which colors it more or less strongly, according to the quantity of coloring matter contained in the decoction; it only now remains to separate the lake from the surplus liquid, to wash and strain it through a filter, to put it into forms, and dry it in the shade.

2087. *Brown pink or yellow lake.*—The drops made from English berries are dissolved with a strong decoction of the berries of Avignon, *(rhamnus infectorius.)* The mixture is filtered, and to it is added a solution of the sub-carbonate of soda, one-fourth the weight of the berries. The tincture is then precipitated with a solution of alum, in such proportions as that the alkali shall not be more than half saturated. It must then be left undisturbed for twenty-four hours; the liquid must then be drawn off, and as it still contains much coloring matter, a smaller quantity of alkali is to be added, and it is again precipitated with a similar proportion of alum. The precipitate is then washed to carry off the salts.

2088. *Madder lake.*—A fine lake may be obtained from madder by washing it in cold water as long as it gives out color; then sprinkling some solution of tin over it, and setting it aside for some days. A gentle heat may also be applied. The red liquor must then be separated by the filter, and decomposed by the addition of carbonate of soda, when a fine red precipitate will be obtained.

2089. *Brazil-wood lakes.*—Brazil wood is to be boiled in a proper quantity of water for fifteen minutes; then, alum and solution of tin being added, the liquor is to be filtered, and a solution of potash poured in as long as it occasions a precipitate. This is separated by the filter, washed in pure water, mixed with a little gum water, and made into cakes.

2090. *Rose pink.*—Boil logwood in water with a little alum, and pour the solution after being filtered on to powdered chalk. The chalk will absorb the coloring matter, and the pigment called rose pink be formed.

Rouge and pink saucers. See *Ex.* 119.

Blues.

Mountain blue. See *Ex.* 1042.

Zaffre. See *Ex.* 666.

2091. *Cobalt blues.*—The blue oxyde of cobalt vitrified constitutes the fine color known as *smalt;* when ground into a fine powder it is known as *zaffre, azure, royal blue,* and *cobalt blue,* a small quantity of alumina being used to combine with the two last.

2092. *Verditer.*—Dissolve copper filings in dilute nitric acid, (aqua fortis) by a moderate heat, until the acid is saturated; add an equal quantity of water to the solution obtained, which is a nitrate of copper, and proceed to precipitate the oxyde of copper by adding small quantities of caustic lime, until the green substance ceases to be precipitated, or until the liquor has lost nearly all its blue color; throw the whole upon a filter and well wash the precipitate; to which, when nearly dry, must be added from 8 to 10 per cent. of fresh caustic lime, incorporating the whole well together. During the latter process the previous green color will be converted into a blue, forming the pigment verditer.

2093. *Prussian blue.*—This is the ferrosesquicyanuret of iron, accidentally omitted from the ferrocyanurets in page 193. The Prussian blue of commerce is usually prepared by fusing in iron pots equal parts of pearlash (carbonate of potass), and any convenient animal matter, as the horns and hoofs of animals, dried blood, or even leather shavings: the mass swells up, liquifies, and finally becomes quite dry, the whole being continually kept agitated by stirring it with iron spatulas; to the mass, when cool, water is added, to wash out the soluble parts; this after being allowed to clear itself, is drawn off, and then mixed with 1 part of sulphate of iron and 2 of alum, by the addition of which a dirty green precipitate is thrown down; it is then separated from the supernatant liquor, and repeatedly washed with weak hydro-chloric acid, (spirits of salt), finally changing by the absorption of oxygen into the pigment Prussian blue.

The chemical changes resulting from this process are, perhaps, the most complicated of any in the whole range of chemical affinities. The following rough outline may serve to convey an idea of the alterations which take place in the nature of the compounds employed. The animal matter consists of carbon, oxygen, hydrogen, and azote, the carbonate of potass; of potassium, oxygen, and carbon; by the action of heat the various elementary principles are liberated, the azote and carbon unite to form cyanogen, (which see.) This again unites with the potassium, forming cyanuret of potassium; other compounds are formed, not essential to the production of the pigment, some of which are liberated in the form of gas. Upon the addition of the water, the cyanuret of potassium is dissolved, and by the further addition of the sulphate of iron, the cyanogen quits the potassium to combine with the iron, forming the insoluble ferrosesquicyanuret of iron, or Prussian blue. By a process differing slightly from the preceding, an amber colored salt is obtained, forming beautiful tables or plates of crystals, called ferrocyanuret of potass, from which compound Prussian blue should always be manufactured for the artist.

2094. *Antwerp blue* differs from Prussian blue simply in containing the earth alumina, by which it is rendered lighter in color; it may be obtained by precipitating the base of alumina, (which see), and afterwards mixing with it the Prussian blue until the required tint is obtained.

2095. *German blue.*—This is a similar pigment; an oxyde of antimony being made to supply the place of the alumina in the preceding; in tint, it occupies a middle place between Antwerp blue and ultramarine.

Thenard's blue, or ultramarine. See *Ex.* 1376.

2096 *Blue ashes.*—This is a precipitate of copper, combined with water (a hydrated carbonate): it is either natural or artificial.

It is only employed in decorative painting; and turns green after some time when used in distemper. The same effect will be produced on it in a few days, if ground up in oil. In preparing this color they begin by making what are called "green ashes," by precipitating by carbonate of potass a solution of sulphate of copper. This carbonate of copper is converted into blue by mixing it with lime and sal ammoniac thus:—take 24 pounds of this precipitate, well washed and filtered, 2 pounds of good quick-lime, and about 10 ounces of sal ammoniac; the lime is then to be slacked to a milky consistency, and made very smooth; the sal ammoniac, reduced to powder, is then added to it, and they must be well stirred, to unite them properly. It is allowed to cool as much as possible previous to mixing with it the carbonate of copper; for during this operation the temperature rises considerably, and should it reach to 25 degrees the hydrate would be decomposed, and a black oxyde would be formed, instead of a bright blue. Either we should have a grey, or a bluish grey color. The mixture is allowed to settle for twenty-four hours, and is then washed in plenty of water.

Greens.

Brunswick green. See *Ex.* 926.

Scheele's, or emerald green. See *Ex.* 111, 1428.

Sap green. See *Ex.* 152.

Mineral green, mountain green, green verditer. *Ex.* 1042.

Verdigris. *Ex.* 1617.

DYEING.

The art of dyeing is truly a chemical process, depending wholly upon the affinity which certain substances, called dye drugs, have for wool, cotton, silk, or other material to be dyed. Some colors adhere at once to the stuff; these are called *substantive* colors, while there are others only to be attached by the intervention of saline or metallic substances, which having an affinity for both the stuff and the coloring matter unite the two together. The following are the principal mordants used by the dyer:—

2097. *Aluminous mordant for reds and pinks.*—Take 1 gallon of boiling water, 2 lbs. of alum, 3 ounces of carbonate of soda in crystals, 1½ lb. acetate of lead. First dissolve the alum, then add the soda, and, when the effervescence has ceased, the acetate of lead, previously pulverized. The mixture being allowed to settle, the supernatant liquor is the mordant. For madder reds add ½ lb. more of the acetate of lead. For yellow dyes take away 1 ounce of soda and ½ lb. of acetate of lead from the first receipt.

2098. *Mordant for black, &c.*—The pyrolignite (acetate) of iron, called iron liquor in this country, is the only mordant used in calico printing for black, puce, violet, and brown colors. The acetate of alumina, prepared from pyroligneous acid, is much used under the name of *red* and *yellow* liquor, being used for these colors.

2099. *Tin mordant.*—Dissolve in strong nitric acid one-eighth of its weight of sal ammoniac; then add by degrees one-eighth of its weight of tin, and dilute the solution with one-fourth of its weight of water.—*Berthollet.*

2100. *To dye cloth, &c. scarlet.*—This is usually done by two operations. First, for 100 lbs. of cloth, put into the water when luke-warm 6 lbs. of crude tartar, and stir it well. Heat the water, and when too hot for the hand throw in 1 lb. of cochineal in fine powder; stir it up well, and immediately throw in 5 pounds of the tin mordant. When the liquor boils put in the cloth, and boil it for two hours, stirring it about occasionally. Then take it out, and wash it in pure water. The cloth is afterwards boiled for an hour in a second bath, made without tartar of 5½ lbs. of cochineal and 14 lbs. of the tin mordant. Some dyers add cream of tartar to the second process also; others use sea salt in the proportion of 2 ounces to a pound of cloth.

2101. *To dye madder red.*—The yarn or cloth is boiled in a weak alkaline bath, washed, dried, and galled, by steeping the cotton, linen, &c., in a decoction of bruised galls or of sumach. After drying, it is twice steeped in warm alum water, then dried and boiled, in a bath made of ¾ pound of madder to every pound of cotton. It is then taken out, dried, and steeped in a second bath in like manner. The following proportion of ingredients may be adopted. To every 20 pounds of cotton use 14 pounds of madder, 3 pounds of nut galls, 5 pounds of alum, to which ½ a pound of acetate of lead has been first added, and then ¼ of a pound of chalk. The goods when dyed are to be washed in warm soap and water, to remove a dun colored matter which is given out by the madder.

2102. *To dye wool red.*—Take 4½ pounds of cream of tartar, 4¼ pounds of alum, boil the wool gently for two hours; transfer it into a cool place, and wash it next day in pure water. Then infuse for half an hour 12 pounds of madder, and 1 pound of chloride of tin in luke warm water, then filter the whole through canvas. The red dye will remain upon the canvas. The liquor not being required, is thrown away or used for, other purposes; the bath is again filled with clear river water, and heated to 100 Fahr., 2 ounces of alum mordant is then added, the cloth put in, and the liquor gradually raised to the boiling point. It is then removed and washed, and afterwards soaked for ¼ of an hour in white soap dissolved in water.

2103. *To dye silks, cottons, &c., pale red.*—This is also done with madder, the goods being first boiled in the mordant bath diluted, and afterwards in one of madder, but the latter not so strong as the process for a red.

2104. *To dye black.*—The cloth is first impregnated with the mordant of the acetate of iron, and then dyed in a bath of madder and logwood.

2105. *To dye scarlet with lac.*—Lac dye is the watery infusion of stick lac, dried and made up into cakes. It is now almost exclusively employed in England, instead of cochineal, to dye scarlet cloths. This dye is dissolved in a tin mordant, obtained by mixing 3 pounds of tin with 60 of hydrochloric acid. Three quarters of a pint of this solvent is to be added to every pound of the dye, and allowed to digest for six hours. To dye 100 pounds of pelisse cloth, a tin boiler, of 300 gallons capacity, should be filled nearly brimful with water, and a fire kindled under it. When the heat is 150° F. a handful of bran and half a pint of tin mordant is to be thrown into it. The froth which rises is skimmed off, the liquor made to boil, and 10½ pounds of lac dye, previously mixed with 7 pints of the solvent, and 3½ pints of tin solvent, to which half a pound of hydrochloric acid may be added. An instant afterwards, 10½ pounds of tartar and 4 of ground sumach, both tied up in a linen bag, are to be added and suspended in the bath for five minutes. The fire being withdrawn, 20 gallons of cold water and 10½ pints of tin mordant being poured into the bath, the cloth is immersed in it. The fire is then re-kindled, and the liquid made to boil rapidly, and kept at that heat for an hour. The cloth is afterwards washed in pure water.

2106. *To dye pink.*—Immerse the article to be dyed in an aluminous mordant, and afterwards in the coloring matter of a pink saucer. See *Ex.* 119.

2107. *To dye yellow.*—Boil the article first in an aluminous mordant, and then in a bath of quercitron bark, Persian berries, weld, fustic, annatto, turmeric, or other dye drug, according to the tint required.

2108. *To dye Saxon blue, or Chemic blue.*—First boil the article in alum. Add 7 or 8 parts by weight of sulphuric acid to 1 of indigo. They will combine, and form the sulphate of indigo, called also *Chemic blue, or indigo composition.* The acid must be kept quite cold during the solution of the indigo. If it become heated *indigo green* is produced. When dissolved, it is suffered to rest for twenty-four hours, and then diluted with twice its weight of river water. It is in this state much contaminated with various bodies, which must be separated; for this purpose wool is immersed in it, previously diluted. This takes a fine dark blue color, leaving the liquor of a greenish yellow. It is then taken out, drained, washed in running water, then put into a copper full of water, with carbonate of potass equal in quantity to one-third the weight of the indigo, and boiled for a quarter of an hour; the blue forsakes the wool, leaving it of a dirty red, and dyes the water blue. This is the real pure blue dye, called *soluble blue or Saxon blue,* and will give a fine and permanent color to any article which has been previously boiled in alum.

2109. *To dye green.*—Boil the article in alum mordant, and then in a bath of indigo, mixed with any of the yellow dyes, until the proper color is obtained.

2110. *To dye wool, &c., brown.*—Brown or fawn color, though in fact a compound, is usually ranked among the simple colors because it is applied to cloth by a single process, and without a mordant. Various substances are used for brown dyes. Walnut-peels, or the green covering of the walnut, when first separated are white internally, but soon assume a brown or even a black color, on exposure to the air. They readily yield their coloring matter to water. They are usually kept in large casks, covered with water, for above a year before they are used. To dye wool brown with them, nothing more is necessary, than to steep the cloth in a decoction of them till it has acquired the wished-for color. The depth of the shade is proportional to the strength of the decoction.

2111. *To dye violet, purple, and lilac.*—Wool is generally first dyed blue, and afterwards scarlet, in the usual manner. By means of cochineal mixed with sulphate of indigo, the process may be performed at once. Silk is first dyed crimson, by means of cochineal and then dipped into the indigo vat. Cotton and linen are first dyed blue, then galled, and soaked in a decoction of logwood; but a more permanent color is given by means of oxyde of iron.

2112. *To dye olive, orange, and cinnamon colors.*—When blue is combined with red and yellow on cloth, the resulting color is olive. Wool may be dyed orange, by first dyeing it scarlet, and then yellow. When it is dyed first with madder, the result is a cinnamon-color. Silk is dyed orange by means of carthamus; a cinnamon-color by logwood, Brazil wood, and fustic mixed together. Cotton and linen receive a cinnamon color by means of weld and madder; and an olive color by being passed through a blue, yellow, and then a madder-bath.

2113. *To dye grey, drab, and dark-brown colors.*—If cloth is previously combined with brown oxyde of iron, and afterwards dyed yellow with quercitron bark, the result will be a drab of different shades, according to the proportion of mordant employed. When the proportion is small, the color inclines to olive or yellow; on the contrary, the drab may be deepened, or *saddened*, as the dyers term it, by mixing a little sumach with the bark.

The colors of goods are so infinitely varied, that it is impossible that we can convey an adequate idea of the important art of dyeing; the foregoing remarks therefore are to be considered as intended merely to show the chemical principles of the art; its further details belong to works of greater extent. The few following receipts for staining wood, ivory, &c., may be useful.

STAINING OR DYEING IVORY.

2114. *Black dye.*—If the ivory be laid for several hours in a dilute solution of neutral nitrate of pure silver, with access of light, it will assume a black color, having a slightly green cast. A still finer and deeper black may be obtained by boiling the ivory for some time in a strained decoction of logwood, and then steeping it in a solution of persulphate, or the acetate of iron.

2115. *Blue dye.*—When ivory is kept immersed a longer or shorter time in a dilute solution of sulphate of indigo, (partly saturated with potash,) it assumes a blue tint of greater or less intensity.

2116. *Green dye.*—This is given by dipping blued ivory for a little while in solution of nitro-muriate of tin, and then in a hot decoction of fustic.

2117. *Yellow dye* is given by impregnating the ivory first with the above tin mordant, and then digesting it with heat in a strained decoction of fustic. The color passes into orange, if some Brazil wood has been mixed with the fustic. A very fine unchangeable yellow may be communicated to ivory by steeping it eighteen or twenty-four hours in a strong solution of the neutral chromate of potash, and then plunging it for some time in a boiling hot solution of acetate of lead.

2118. *Red dye* may be given by imbuing the ivory first with the tin mordant, then plunging it in a bath of Brazil wood, cochineal, or a mixture of the two. Lac-dye may be used with still more advantage to produce a scarlet tint. If the scarlet ivory be plunged for a little time in a solution of potash it will become cherry red.

2119. *Violet dye* is given in the logwood bath to ivory previously mordanted for a short time with solution of tin. When the bath becomes exhausted it imparts a lilac hue. Violet ivory is changed to purple red by steeping it a little while in water containing a few drops of nitro-muriatic acid.

With regard to dyeing ivory it may in general be observed, that the colors penetrate better before the surface is polished than afterwards. Should any dark spots appear, they may be cleared up by rubbing them with chalk; after which the ivory should be dyed once more to produce perfect uniformity of shade. On taking it out of the boiling hot dye bath, it ought to be immediately plunged into cold water, to prevent the chance of fissures being caused by the heat.

STAINING WOOD, ETC.

2120. *Black stain.*—Boil ½ a pound of chip logwood in two quarts of water, add 1 ounce of pearl-ash, and apply it hot to the work with a brush. Then take ½ a pound of logwood, boil it as before in 2 quarts of water, and add ½ an ounce of verdigris, and ½ an ounce of copperas; strain it off, put in half a pound of rusty steel filings, with this go over the work a second time.

2121. *To stain beech a mahogany color.*—Put 2 ounces of dragon's blood, broken in pieces, into a quart of rectified spirits of wine; let the bottle stand in a warm place, shake it frequently. When dissolved it is fit for use.

2122. *To imitate rose-wood.*—Boil ½ a pound of logwood in 3 pints of water till it is of a very dark red; add ½ an ounce of salt of tartar. While boiling hot, stain the wood with two or three coats, taking care that it is nearly dry between each; then with a stiff flat brush, such as is used by the painters for graining, form streaks with the black stain mentioned in *Ex.* 2119, which, if carefully executed, will be very nearly the appearance of dark rose-wood.

2123. *To imitate King or Botany Bay wood.*—Boil ½ a pound of French berries in 2 quarts of water, till of a deep yellow; and, while boiling hot, give two or three coats to the work. When nearly dry, form the grain with the black stain, which must also be used hot. You may, for variety, to heighten the color, after giving it two or three coats of yellow, give one of strong logwood liquor, and then use the black stain as directed.

2124. *Red stain for bedsteads and common chairs.*—Archil, as sold at the shops, will produce a very good stain of itself when used cold; but if, after one or two coats being applied and suffered to get almost dry, it is brushed over with a hot solution of pearl-ash in water, it will improve the color.

2125. *To improve the color of any stain.*—Mix in a bottle 1 ounce of nitric acid, ½ a tea-spoonful of hydrochloric acid, ¼ of an ounce of grain tin, and 2 ounces of rain water. Mix it at least two days before using, and keep the bottle well corked.

2126. *To stain horn in imitation of tortoise-shell.*—Mix an equal quantity of quick-lime and red-lead with strong soap lees; lay it on the horn with a small brush, in imitation of the mottle of tortoise-shell. When dry, repeat it two or three times.

BLEACHING.

Bleaching by chlorine. See *Ex.* 291, 292.

Bleaching by euchlorine. See *Ex.* 773.

Bleaching by sulphurous acid. See *Ex.* 814.

Bleaching cotton goods. See *Ex.* 293.

Bleaching by sulphur. See *Ex.* 375.

Manufacture of bleaching powder. See 903, 905.

2127. *Bleaching ivory.*—Ivory is very apt to take a yellow-brown tint by exposure to air. It may be whitened or bleached by rubbing it first with pounded pumice-stone and water, then placing it moist under a glass shade luted to a stand at the bottom, and exposing it to sunshine. The sunbeams without the shade would be apt to occasion fissures in the ivory. The moist rubbing and exposure may be repeated several times.

Cleaning leather and boot tops. See *Ex.* 1506.

Removing ink spots. See *Ex.* 1592.

2128. *Bleaching straw hats.*—They are first washed with soap and water, and then placed in a box along with burning sulphur for an hour.

2129. *Bleaching bees' wax.*—Wax is freed from its impurities by melting it with hot water or steam, in a tinned copper or wooden vessel, letting it settle, running off the clear supernatant oily-looking liquid into an oblong trough with a line of holes in its bottom, so as to distribute it upon horizontal wooden cylinders, made to revolve half immersed in cold water, and then exposing the thin ribbons or films thus obtained to the blanching action of air, light, and moisture. For this purpose, the ribbons are laid upon long webs of canvas stretched horizontally between standards, two feet above the surface of a sheltered field, having a free exposure to the sunbeams. Here they are frequently turned over, then covered by nets to prevent their being blown away by winds, and watered from time to time, like linen upon the grass field in the old method of bleaching. Whenever the color of the wax seems stationary, it is collected, re-melted, and thrown again into ribbons upon the wet cylinder, in order to expose new surfaces to the blanching operation. By several repetitions of these processes, if the weather prove favorable, the wax eventually loses its yellow tint entirely, and becomes fit for forming white candles. If it be finished under rain, it will become grey on keeping, and also lose in weight. Neither chlorine, nor even the chlorides of lime and alkalis, can be employed with any advantage to bleach wax, because they render it brittle, and impair its burning quality.

2130. *Removing stains from books, &c.*—Dissolve chloride of soda in water, and wash it over the print, &c., which will restore much of its original clearness of color; and, unless the mixture be very strong, the texture of the paper and color of the ink will not be injured.

2131. *Bleaching discolored pearls.*—Let them lie in a paste of magnesia and water for from two to twenty-four hours, according to the discoloration. Some persons soak them in lime water.

2132. *Bleaching sponge.*—To render it perfectly white it is necessary to soak it in cold water, but if it does not become soft it must be immersed in boiling water. This, however, should if possible be avoided, for it has a bad effect on the sponge, particularly in cooling; it causes it to shrink and to become hard, and so tough as to prevent its being bleached. Let the sponge be soaked in cold water, and that water be changed three or four times every day, and at every time that the water is drawn off let the sponge be pressed perfectly dry. This process being repeated for five or six days, it will, at the expiration of that time, be ready for bleaching. If the sponge, as is frequently the case, should contain small pieces of chalk and shells, which cannot be got out without tearing it, the sponge must be soaked for twenty-four hours in hydrochloric acid, with twenty parts of water, which will cause an effervescence to take place, and carbonic acid gas to be liberated, when the shells and chalk will become perfectly dissolved. After that it must be carefully washed in fresh acid and water, the specific gravity of which must be 1.024. The immersion of the sponge in this should continue for about eight days; but it must occasionally be pressed dry and thoroughly washed. After having been perfectly washed and cleaned, it should be sprinkled with rose water to give it a pleasant smell, which completes the process.

2133. ***Ordinary process of bleaching cotton goods.***—The first process is steeping, or rather boiling the goods in water, in order to remove all the substances soluble in that liquid. The next step is to wash or scour the goods by the dash-wheel or the stocks. This is of great importance in the course of bleaching, and must be repeated several times; so much so, that in winter, when the water of the dash-wheel is cold, the bleaching is more tedious and difficult. Yarn and very open fabrics do not much need the dash-wheel. By these first two operations, the woven goods lose about sixteen per cent. of their weight, while they lose only two parts out of five hundred in all the rest of the bleaching.

In the third place the calicoes are boiled with milk of lime, whereby they are stripped of their gluten, and acquire a portion of calcareous soap. Formerly, and still in many bleach-works, the gluten was got rid of by a species of fermentation of the farinaceous dressing; but this method is liable to several objections in reference to the calico printer.

The goods are now subjected to a caustic soda ley, which dissolves out the soaps of lime and copper, as well as that portion of the coloring matter which is sufficiently dis-hydrogenated to be capable of combining with it. When the goods are sufficiently *bucked* in the leys, they are either exposed to chlorine, or laid out on the grass; sometimes both are had recourse to for delicate work. These different modes of action have the same influence on the coloring matter, but they give rise to different effects in reference to greasy stains. The goods are dipped in a solution of chloride of lime, which should be kept tepid by means of steam. Alongside of the chlorine cistern there is another filled with dilute sulphuric or muriatic acid. When the goods are taken out of the chlorine they are drained on the top of its cistern till no more liquid runs off them, and they are then plunged into the *sour*. The action of the acid in the present case may be easily explained. In proportion as a salt of lime is formed, this base quits the chlorine, and allows it to act freely upon the coloring matter. Thus we prevent the development of too great a quantity of chlorine at once, which would be apt to injure the fibres; and we pursue both a prudent and economical plan. Only so much chlorine as is strictly necessary is called forth, and hence it excites no smell in the apartment. The chlorine serves to acidify the coloring matter, by abstracting a portion of its hydrogen; but we must take the greatest care that there is no grease upon the goods before immersion in it, for the consequence would be very troublesome spots. When the cloth is laid out upon the grass, it is the oxygen of the air which acidifies the coloring matter; for which reason, the dew, which contains much air rich in oxygen, singularly accelerates the bleaching process.

The goods must now receive a new soda ley, to dissolve out that portion of the coloring matter which has been dis-hydrogenated in the chlorine of the air, as well as the grease, if any perchance remained in the soluble state. These last two operations are to be several times repeated, because the coloring matter should be removed only by degrees, for fear of injuring the texture of the goods, by subjecting them to too much chlorine at a time.

We finish with the dilute sulphuric acid, which should be very weak and tepid. It dissolves out the iron, and some earthy matters occasionally found upon cotton. The goods must be most carefully washed at the dash-wheel, or in a stream of water on quitting the sour bath, for if the acid were allowed to dry in them, it would infallibly injure their texture by its concentration. In winter, if the goods are allowed to get frozen with the acid upon them, they may also be damaged. We may here observe, that when the goods are not to remain white, their bleaching may be completed with a ley; for though it leaves a faint yellow tint, this is no inconvenience to the dyer. But when they are to be finished with a starching after the last ley, they must have another dip in the chlorine to render the white more perfect. An immersion in the dilute acid has nearly the same effect.

2134. *Paper bleaching.*—This title comprehends two different processes: one for bleaching rags, and other materials from which paper is at first fabricated, and another for refabricating paper from old written or printed papers. We are chiefly indebted to the French chemists for these processes, which may be seen in various parts of the "Annales de Chimie," and in Des Charmes' "Art of Bleaching." Rags, when grey or colored, are to be separated and ground in the paper-mill in the usual way, till brought to a sort of uniform consistence, having been previously macerated according to their quantity and tenacity. The mass is then treated with an alkaline ley, similar to what has already been directed for piece goods. It is next treated with any of the preparations of chlorine, which is thought most convenient; the chloride of lime is most usually employed. If this immersion do not produce the desired effect, which does not often happen if the colors are tenacious, such as red and blue, let the treatment with the alkaline leys be repeated, and follow it with another bath of the chlorine preparation. Then sour the whole in a bath of sulphuric acid, much diluted and cold, for when hot its action will be less effectual. Water is then to be run upon it till it come off without color or indication of acidity. Black is the most easily discharged color, and will seldom require being treated with ley or steep of sulphuric acid, one bath of alkali and another of chloride of lime being sufficient to produce a good white. Old printed or written paper is first to be sorted according to its quality, and all the yellow edges cut off by the bookbinder's plane. One hundred weight of this paper is to be put sheet by sheet into vats sufficiently capacious, with 500 quarts of hot water. The whole is to be stirred for about an hour, and as much water gradually added as will rise about three inches above the paper, and to be left to macerate for four or five hours. It is then ground coarsely in the mill, and boiled in water for about an hour, taking care to add before it begins to boil, thirteen quarts of caustic alkaline ley. After boiling, it is macerated in the ley for twelve hours, when it is pressed, and is sufficiently white, is forthwith manufactured into paper; if not, the process is repeated. Written paper may be bleached by sulphuric acid alone, and printed paper by alkaline or soap leys, but the above process is the most effectual, and the expense is exceedingly trifling. Paper which has been written or printed may even be bleached without destroying the leaves, by treating them with the same chemical agents, taking care to arrange the sheets alternately between cloths in the same manner as the paper makers dispose their sheets of paper when delivered from the form.

2135. *Straw bleaching.*—Our milliners not pleased with the yellow color, which the straw of which hats are made originally, possesses, or urged by the all-prevailing taste, have lately been desirous of obtaining white straw; and several attempts have been made to bleach this substance with the usual agents. Sulphuric acid has been found to succeed best in those incipient attempts, while the chlorides and the simple chlorine gas are said to injure the texture and destroy the natural varnish of the straw, which is its greatest beauty. It is probable, however, that this has proceeded from unskilful management, for in other departments of bleaching, the corrosive effects of the chlorine when combined with earths or alkalies, and properly diluted, are found to be as easily prevented as that of sulphuric acid, while its power of destroying a color is greatly superior.

2136. *Silk bleaching.*—The Chinese mode of bleaching silk without boiling or ungumming it, is supposed to have been discovered by M. Baume, who has given an elaborate memoir on the subject, *Jour. de Phys.* 1793. M. Baume directs to dispose 6 pounds of yellow raw silk in a stone ware vessel, and to pour over it a mixture previously made of about 48 pints of spirits of wine, and 12 ounces of very pure hydrochloric acid, the whole being then covered up and left to digest, till the liquor change from green to yellowish brown. The liquid is then drawn off, and unmixed spirits of wine is poured upon the silk till it come off colorless; it is then allowed to drain when it is ready for a repetition of the process. The second steeping continues longer than the first. The third maceration is made in pure spirits of wine for a day, when it is drained and sprinkled with water to recover all the spirit; it is then washed clear of the acid by putting it in a woollen bag, and keeping it in a running stream for six hours. The water and the hydrochloric acid ought to be completely free from the nitric acid, otherwise the goods will be spoiled. Rigand found the process to be one half speedier when the vessels were exposed to the sun.

2137. *Another method.*—When the silk is to be deprived of its gum, the process is different. A ley of white soap is made by boiling in water 30 lbs. of soap for every 100 lbs. of silk intended to be bleached, and in this the silk is steeped till the gum is dissolved and separated. It is then put into bags of coarse cloth and boiled in a similar ley for an hour. By these processes it loses 25 per cent. of its original weight. The silk is then thoroughly washed and steeped in a hot ley composed of 1 pound and ½ of soap, 90 gallons of water, with a small quantity of litmus and indigo diffused. After this it is carried to the sulphuring room: 2 pounds of sulphur are sufficient for 100 lbs. of silk. When these processes are not sufficiently successful, it is washed with clear *hard* water and sulphured again.

2138. *Wool bleaching.*—Wool is commonly bleached by means of fumes arising from the slow combustion of sulphur. The wool is first prepared according to the purposes for which it is intended, by treating it with solutions of soap. By this process, it is cleared of a great quantity of loose impurity and grease which is always found in wool, often losing no less than 70 per cent. of its weight. The heat of the ley must be carefully attended to, as a high temperature is found to fix the unctuous matter or yolk of the wool. After washing, it is taken to the sulphur chamber, where it is exposed to the vapor from 5 to 20 hours according to circumstances. This is again washed, and then immersed in a bath composed of pure whitning and blue. It is then exposed a second time to the fumes of the sulphur, and washed with a solution of soap which renders it of the proper whiteness.

FREEZING MIXTURES.

Ex. 2139. If a thermometer be fixed in a pan of snow over a fire, it will, if higher than 32°, sink down to that point, and remain there until the snow is completely converted into water. After the snow has been melted, the thermometer will rise in proportion as more heat is applied; and will continue to do so until it arrives at 212°, the boiling point. Here the snow has been receiving a continual supply of heat from the fire: but this was necessary to change it into, and to preserve it in a liquid state. The heat which entered the water after being rendered fluid may be termed *sensible* heat, because the thermometer indicates the different degrees of heat which the water may afterwards receive. The cause of the sinking of the thermometer in the first instance to 32°, is, that it imparts to the snow the surplus of its own heat above 32°, to assist in melting it.

2140. If any weight of snow, or pulverized ice at 32°, be mixed with an equal weight of water at 172° it would naturally be expected that the temperature of the mixture would be 102°, or one half. But this will not be the case; for if the thermometer be applied the temperature of the whole will be found to be only 32°. It seems strange, that the snow or ice should have no addition of caloric, whilst the water has suffered an abstraction of 140°. But it is evident that the use to which the 140° were applied was to liquify the snow, without increasing its temperature. Therefore, water at 32° requires 140° of latent caloric to preserve it in a liquid state;—it cannot freeze until it has parted with that number of degrees; and, on the other hand, ice cannot melt, until it has derived 140° of latent heat from surrounding bodies.

2141. If, when the temperature of the air is at 22°, a cyder-glass be half filled with spring-water, and a thermometer be placed in it, (the top of the glass being covered,) the water will cool down gradually to 22°, without freezing. But if gently agitated, it will instantly freeze into a mass, similar to snow which is thawing; and the temperature will immediately rise to 32°, the freezing point: — thus deriving the 10° of caloric which were latent or concealed from the previous fluid state of the water. This quantity of caloric could not before have been indicated by the thermometer; consequently it was latent, or so combined with the particles of the water, as to seem to have changed its state. The same operation of latent caloric takes place in every other substance, such as metals, wax, tallow, &c.:—the first owe their ductility and malleability, and the last their softness and plasticity, to latent caloric.

2142. If water be heated to 400° in a Papin's digester, and the vessel be suddenly uncovered, one-fifth part will rush out in the form of steam; and the temperature of the remaining water will, at the same instant, sink down to 212°, (the boiling point,) losing no less than 188°, the difference between 400 and 212. These 188° must have become latent, and must have combined with one-fifth of the water to form the steam; for if the thermometer be applied to the steam, it also will be found to be only at 212°. Now only one-fifth of the water was converted into steam; consequently, in addition to its own 188°, it must have deprived the other four-fifths each of their 188°; and 188 multiplied by 5, produces 940, which is pretty near to 1000°; the quantity of latent caloric required to keep steam in its elastic form. Steam must part with an immense quantity of heat before it is condensed into water; and with much more before it can be converted into ice.

The following experiments prove, that when expansion of volume takes place during the combination of substances; heat is absorbed from the surrounding atmosphere, or from any other body that comes in contact with the vessel containing the mixture. The body from which the heat has been absorbed is, of course, rendered cold. The cold produced by the following compounds is so intense that they have justly been denominated freezing mixtures.

2143. *Hydrochlorate of ammonia and nitrate of potass.*—Pulverise 5 drams of hydrochlorate of ammonia and 5 drams of nitrate of potass; and add 2 ounces of water to them, in a tin, stoneware, or glass vessel. If you plunge a thermometer into the mixture, the mercury will sink from + 50° to—10, that is 40°; denoting the degree of cold produced. This mixture will freeze oil of turpentine, wine, water, sea-water, milk, and vinegar.

2144. *Sulphate of soda and sulphuric acid.*—A mixture of 5 drams of sulphate of soda, and 4 drams of diluted sulphuric acid, will lower the temperature of the thermometer 47°; that is, from + 50° to + 3°. Sulphuric acid of various strengths will freeze in this mixture.

2145. *Nitric acid with several salts.*—Mix together 6 drams of sulphate of soda, 4 drams of hydrochlorate of ammonia, 2 drams of nitrate of potass, and 4 drams of dilute nitric acid. This mixture will lower the thermometer from + 50° to—10°, which is 60°.

2146. *Snow with nitric acid.*—Mix 7 drams of snow with 4 drams of diluted nitric acid. If the thermometer be at + 32° it

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THE END.

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